The Engineer

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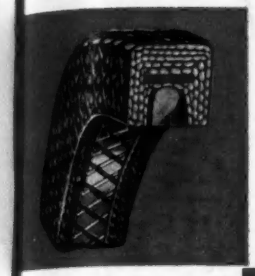

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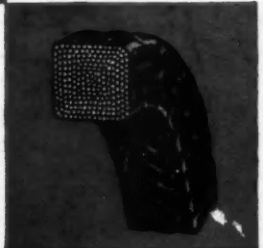

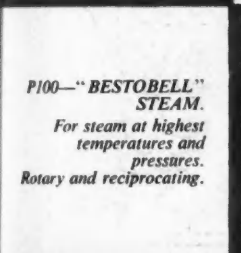

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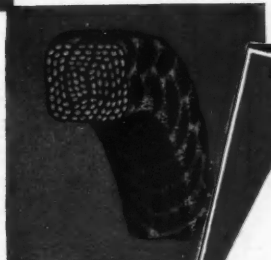

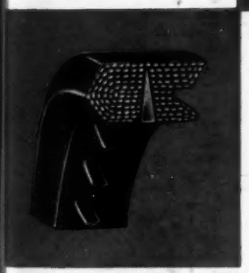

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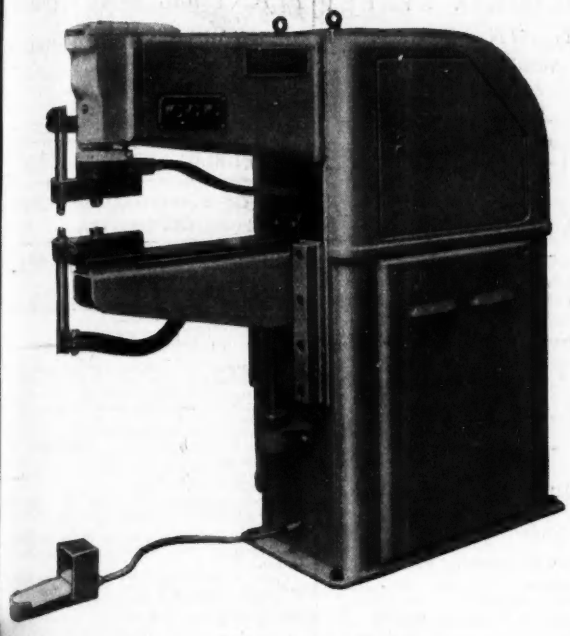

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THE ENGINEER

ESTABLISHED 1856

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Telephone: CENtral 6565

Vol. 204 No. 5316

DECEMBER 13, 1957

Published every Friday Registered as a Newspaper

PRINCIPAL CONTENTS

(Complete contents on page 847)

Report on Dip. Tech 847

Fuel and Power 848

Trade Fairs in Britain 848

Effects of Heated Discharges on the Temperature of the Thames Estuary—No. II 850
(A. L. H. GAMESON, H. HALL AND W. S. PREDDY)

Modern Tendencies in Arch Dam Design—No. I 853
(S. LELIAVSKY)

Strip Mill with Automatic Gauge Control 860

Water Treatment at Pitsford Works 863
(J. W. MILNE)

Welding Gantry for Shipyards 865

Work of the U.S. Atomic Energy Commission—No. III 878

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INDEX TO ADVERTISERS ..... PAGE 161

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December 18–20	Machine tools and miscellaneous stores, including radio and electrical test equipment	Technical Stores Depot, Old Dalby, Melton Mowbray, Leics. (Sale at Melton Mowbray.)	SHOULER & SON (Dept. L), 1, Norman Street, Melton Mowbray, Leics. (Tel.: 81.)
December 18	Miscellaneous stores, including women's greatcoats, overalls, jerseys, skirts, boots, shoes, &c.	Command Ordnance Depot, Kinnegar, Co. Down, Northern Ireland. (Sale at Belfast.)	OSBORNE KING & MEGRAN (Dept. L), 14, Montgomery Street, Belfast, N.I. (Tel.: 30433.)
1958			
January 7	Miscellaneous stores, including clothing, large quantity of boots, &c.	Central Ordnance Sub-Depot, Westbury, Wilts. (Sale at Corn Exchange, Devizes.)	FARRANT, WIGHTMAN & PINNIGER (Dept. L), 38, High Street, Swindon, Wilts.) (Tel.: 5151/2.)
January 9	Miscellaneous stores, including furniture, hardware, hand tools, textiles, cordage, &c.	General Stores Sub-Depot, Longtown, Nr. Carlisle. (Sale at County Hall, Carlisle.)	HARRISON & HETHERINGTON, LTD. (Dept. L), Botchergate, Carlisle. (Tel.: 26292/3.)

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THE ENGINEER

VOL. 204 No. 5316 DECEMBER 13, 1957

CONTENTS

LEADING ARTICLES—
Report on Dip. Tech. 847
Fuel and Power 848
Trade Fairs in Britain 848

ARTICLES—
Boiler Availability Committee 862
Building for Atomic Energy... 849
Charting the Seas 849
Completion of Wemmershoek Dam for Cape Town 875
Concrete Vibrators. (Illus.)... 873
Conference of Commonwealth Engineering Institutions 849
Detector for Flow Failure in Solid Materials... 871
Effects of Heated Discharges on the Temperature of the Thames Estuary. No. II. (Illus.) 850
Electrical Generating Equipment for Aircraft. (Illus.) 868
Electronic Equipment for Measuring Road Vehicle Speeds. (Illus.) ... 870
Framework of Transport 857
Gate-End Box. (Illus.)... 872
Hobbing Machine. (Illus.) 872
Kelvin Power Station. (Illus.) 875
Long Corrugated Aluminium Sheets. (Illus.) 873
Meetings on Nuclear Energy... 872
Modern Tendencies in Arch Dam Design. No. I. (Illus.)... 853
Modernised Machine Tool Works. (Illus.) 871
Nuclear Power in Southern Italy... ... 849
Programme Machine for Northern Line Signalling. (Illus.)... 870
Ram-Jets. (Illus.) 867
Reasoning of Europeans 869
Reorganisation of Electricity Supply Industry 849
Strip Mill with Automatic Gauge Control. (Illus.) 860
Water Treatment at Pitsford Works. (Illus.) 863
Welding Gantry for Shipyards. (Illus.) 865

CONTINENTAL SECTION—
Demountable Truck Bodies. (Illus.)... 876
Aerial Ropeways at Cologne. (Illus.)... 876
1000-Ton Quick-Acting Forging Press. (Illus.) 877

AMERICAN SECTION—
Work of the U.S. Atomic Energy Commission. No. III. (Illus.) ... 878
Universal Transfer Arm... 881

LITERATURE 858

NEWS AND NOTES—
Advanced Engineering Courses 884
British Patent Specifications. (Illus.)... 883
Forthcoming Engagements 884
Industrial and Labour Notes... 874
Launches and Trial Trips 884
Personal and Business 882
Technical Reports 859
100 Years Ago... 848

REPORT ON DIP. TECH

The National Council for Technological Awards has issued its first report. The Council, it will be recalled, was appointed two years ago by the Minister of Education as an " independent self-governing body to create and administer technological awards of high standing having a national currency and available to students in technical colleges who successfully complete approved courses." The Council has a governing body, over which Lord Hives presides, and two boards of studies, one for engineering and the second for technologies other than engineering. So far, one award, the Diploma in Technology has been established and for the past fifteen months the Council has been considering, very carefully, applications from technical colleges for recognition of courses leading to this award. From the outset, it was made clear that the Dip. Tech. was to be an award which would leave the technical colleges, and the industries they serve, a large measure of freedom in planning the education of their students. But it was made equally clear that the Council would insist on high standards, both with regard to the academic content of the courses and the environment of the colleges where they could be conducted.

A study of the report leaves the impression that a good start has been made, although there are not yet nearly enough technical colleges whose accommodation, equipment and teaching resources enable them to reach the standards set by the Council. But between August, 1956 and the end of last July, 123 applications for approval of courses were made by twenty-eight colleges ; in the same period, twenty-nine existing courses were recognised as leading to the Diploma, the arrangements for conducting twenty proposed new courses satisfied the Council's requirements and thirty-four courses were rejected as not suitable. Nevertheless, there are now 965 students taking one or other of thirty-seven approved courses in eleven technical colleges. The individual syllabuses in a particular subject have shown some variation between one college and another, in accordance with the needs of the industry concerned. That was to be expected. The important thing is that in all the courses so far recognised as leading to the Diploma, the Council is satisfied that " the study of fundamental science and technology and their application to development and design, provides a course of disciplined study fully equivalent to that leading to a university honours degree." Next year, further progress may be expected, for in June one of the approved colleges—the Birmingham College of Technology—is to conduct the first of the final examinations for Dip. Tech. When some awards have actually been made, everybody concerned will be in a better position to assess the real merit of a scheme that has undoubtedly got off to a satisfactory start. In the first eighteen months of its activity, the National Council for Technological Awards has carried out a great deal of the spade work essential to the improvement of technological education in this country. The Council recognises, however, that much remains to be done. The report emphasises the need for more full-time and sandwich courses in the technical colleges ; it emphasises also that their achievement is dependent upon new buildings, strengthened teaching staffs, the introduction of a " more liberal atmosphere " and the development of much closer links between the colleges and industry. As Lord Hives so aptly said, when presenting the report last week, " the colleges have been doing a good job, often in very depressing circumstances ; what they need now is stimulation and encouragement."

For many years past the work of technical colleges throughout the country has regularly received the support and encouragement of a large number of industrial concerns. Yet there is room for more ! The valuable contribution which many firms in industry are making to technical education and training does not always, perhaps, receive as much publicity as it deserves. But if an adequate complement of trained technologists for present and future requirements is to be ensured, then the smaller as well as the larger units of industry must gear themselves to take an even bigger interest in the work of the technical colleges. Enthusiastic collaboration between industry and the colleges will go a long way towards bringing about the fulfilment of the aims not only of the National Council for Technological Awards, but of all who are at present deeply concerned about technical education in this country.

FUEL AND POWER

The House of Commons recently debated the motion "That this House takes note of the latest Annual Reports and Statements of Account of the Gas and Electricity Industries." The House duly took note of them. But the debate was very disappointing. There was for the most part concentration upon matters of detail; and even Mr. Gerald Nabarro, usually well informed upon such matters, was not at his best. He laid the blame, for example, for the relatively low load factor of power generation by electricity stations, not, it is true, upon the Central Electricity Authority—which would have been rather ridiculous—but upon the Government. In fact, of course, load factor must fluctuate mainly with industrial activity and with the extent to which industry can persuade the trade unions that shift working would be an advantage. Unaccustomedly, Mr. Nabarro was speaking in irritating half-truths instead of direct to the point. He repeated the error in his reference to thermal efficiencies. There, he compared a reported thermal efficiency of the gas industry of 77·8 per cent with the thermal efficiency of electric power stations of a "mere" 24·93 per cent, and said that the country's "largest single consumer of solid fuel, 42,000,000 tons a year approximately" was "wasting" three-quarters of that huge quantity of fuel. This is, of course, far too crude a comparison, as Mr. Nabarro must well know himself. What, for example, is the overall thermal efficiency if the gas is used for the generation of power? How do the economics work out when the gas is used for the generation of heat? Even for the latter purpose the choice, whether of gas or electricity, usually depends upon local factors or upon the particular heating process involved. Only when he came to criticise a taxation policy which applies 60 per cent purchase tax to appliances using gas and electricity generated from home produced fuel and none to appliances using imported oil, was Mr. Nabarro on surer ground.

But the chief defect of the Debate was its failure to look to the future. Perhaps the rules of debate forbade it. Perhaps members were wary of treading ground which angels might fear to tread upon. Certainly little if any reference was made to the situation which will arise on and after January 1 next, when the Area Boards of what is now the Central Electricity Authority become autonomous and a new Generation Board is set up. We, too, rather fear to tread upon that ground. Substantial reorganisation is involved, including, in accordance with announcements published elsewhere in this issue, agreements between the new Electricity Council and the new Central Electricity Generating Board about the detailed limits of their respective responsibilities and the degree of autonomy to be exercised by the latter and by the Area Boards and Generating Divisions. It is too early yet awhile to comment in detail upon most of the arrangements made or in the making. But there is one matter which worries us. Both within the gas and coal industries there appears to be reasonably adequate provision for research over and above that done by the Fuel Research Laboratory. The electrical industry has, of course, its Electrical Research Association and individual manufacturing firms undertake much research. There remains, however, a field which we considered, hardly adequately covered by research organisations under the Central Electricity Authority, such as that at Leatherhead, yet particularly appropriate for that Authority to encourage. That field relates to problems of generation and more particularly to problems of transmission and the operation of large high-voltage interconnected systems. How, we wonder, and under whose specially interested authority, is future research going to be pushed forward in these and other related fields once the existing Authority has been broken up and the Area Boards and the Generating Boards become autonomous? The decision has been made that research staff at Leatherhead shall come under the control for the present of the Generation Board, until such time as further study has been given to the matter. For our part, we wonder whether it would not be better for the Council, likely to take a broader and more critical view of matters particularly requiring study, to retain, not only the responsibility for research, laid upon it by the Act, but full control as well.

The Engineer
100 Years Ago

(DECEMBER 11, 1857)

"TELEGRAPHIC COMMUNICATION WITH INDIA"

"Lord Palmerston stated in the House of Commons the other evening that Her Majesty's Government had been in communication with the Government of Austria upon the subject of a telegraphic line to be established from Ragusa to Alexandria, but the conditions which the Austrian Government wished to attach to the treaty were such that Government could not with propriety agree to, and therefore that negotiation has been dropped. One of those conditions was that the British Government should engage to use no other line but that for its communication with India; and another was that we should undertake to continue the line from Suez to India. Of course, the first was sufficient, that being a condition which Government did not think it advisable to accept, and the second was a condition which they did not see their way easily to fulfil. That negotiation is therefore for the present at an end; but at the same time hopes are entertained that the Austrian Government will establish such a line of communication, because it is obvious that it would be advantageous for them to do so, and it would be very desirable to us to have it."

TRADE FAIRS IN BRITAIN

Last July the Birmingham Chamber of Commerce announced that next year there would be no British Industries Fair at Birmingham. It also said that it would no longer be responsible for organising such a fair on the existing all-British basis. But it showed some enthusiasm for the organisation of an international fair. For our part, in commenting upon the matter, we expressed the views that British industry was not in favour of the holding of great international fairs on the Continental model and that in any case Castle Bromwich was not the place to hold them.

Arising out of the action of the Birmingham Chamber of Commerce, the President of the Board of Trade requested the Federation of British Industries to make an inquiry. That inquiry, just completed, shows that the majority of trade associations are opposed to the development in this country of a general international fair covering a wide range of industrial products, similar to those held in most European countries. They favour, instead, the continued development of specialised fairs, that is fairs covering the products of a particular industry. Of 109 trade associations whose members are concerned with trade fairs, no less than 105 favoured specialised fairs and only two showed any decided preference for general fairs. Interestingly, a substantial number indicated that they would like to see the scope of specialised fairs widened sufficiently to allow for the grouping of the products of allied industries. The inquiry also revealed that opinion was about equally divided, among those trade associations which expressed a view, on the question whether specialised trade fairs in Britain should be national or international. This corresponds with the facts of the present situation. Of the sixty specialised fairs held each year in this country about half are national and the other half international.

But the situation remains that there are no exhibition halls in London or elsewhere really suitable for the showing of much of the heavy engineering and other products produced in this country, and that none of the existing halls fully meets modern requirements even for the exhibition of lighter products. There is no need for the provision of around 1,000,000 or more square feet of exhibiting space so as to bear comparison with the space available at Continental international fairs. But there is a need, we feel, for the provision within or close to the centre of London, of a more modest group of halls, one, at least, of which should be equipped with suitable cranes and adequate road and rail access for the exhibition of heavy machinery. We are glad to note that the Federation now proposes to institute a further inquiry into that aspect of the problem.

A Seven Day Journal

Building for Atomic Energy

SIR JOHN COCKCROFT presented a paper on building for atomic energy to the Royal Institute of British Architects on Tuesday last, December 10. He began by saying that there had been a great deal of building for atomic energy since 1946, and that the cost amounted to some £15,000,000 for Harwell alone. Since the conversion of Harwell airfield into a research establishment, and of Springfields and Sellafield munition factories into plants for the production of uranium and plutonium, a gigantic diffusion plant had been built *de novo* at Capenhurst, and additional research establishments had been constructed at Aldermaston and Dounreay. The difference between building for atomic energy and building for more conventional purposes, however, consisted only in the need for protection from radioactivity. Thus, one of the most important new buildings at Harwell had been the Radiochemical Laboratory, and its design had been dominated by the fact that the chemists who were to use it would be working with radioactive solutions. Some of these emitted γ rays, demanding lead shielding walls. Another hazard that had to be guarded against was that chemists did occasionally spill solution on the floor, and ventilation had to be extremely good to cope with any radioactive dust that might result. The most recent reactors, DIDO and PLUTO, were housed in airtight steel buildings, which provided a second line of defence.

The problems of the Industrial Group of the U.K.A.E.A. had been different in scale, but not in kind, continued Sir John. There had been a great deal of public debate on the siting of nuclear power stations. Having outputs up to 500MW, they required cooling water for condensing steam, just as did conventional stations, and the sites had therefore to be on large rivers, estuaries or the coast. Good foundations were necessary for the heavy reactor loads, and the height above sea level had not to be too great. The Government had also added the requirement that stations should not, for the time being, be too near to towns. This specification left only a limited range of sites to choose from, and the designer had to do his best, with architectural advice, to fit the station into the landscape. He could take advantage of the undulating features of the terrain, but he did not have much scope on the Essex flats or the Severn meadows !

Reorganisation of Electricity Supply Industry

DETAILS have been announced of certain aspects of the reorganisation of the electricity supply in ustry, based on the provisions of the Electricity Act, 1957. For example, the organisation of research poses special problems. Since the Electricity Council has an overall responsibility for research in the electricity supply industry, the C.E.A. research laboratory buildings at Leatherhead, Surrey, will be vested in the Council. But, since more than 80 per cent of the current work at Leatherhead concerns the generation and transmission of electricity, it has been agreed that the contracts of service of the staff at Leatherhead will vest in the Central Electricity Generating Board, pending further consideration of the kind of research work to be done by the Council and the Board respectively. The two training centres of the C.E.A. are to be preserved as a residential college of the industry as a whole. The Council will be responsible for the centre at Horsley Towers, Surrey, and the Generating Board for the centre at Buxton, but there will be reciprocal arrangements for some of the courses.

The Central Electricity Generating Board proposes to delegate " more responsibility, autonomy and power " to the provincial establishments. The existing generating divisions will continue as operational management entities and will be grouped under five regional directors as follows : North Eastern and Yorkshire ; Midlands and East Midlands ; Eastern, London and South Eastern ; Southern, South Western and South Wales; and North West, Merseyside and North Wales. Although the existing technical organisations will remain under the divisional controllers, accountancy and some administrative functions will gradually be brought together at the regional offices.

The character of the industry's growth makes it impossible to achieve a uniform load on the construction staffs of the eleven divisions and even, to some extent, of the five proposed regions. Accordingly, three separate engineering project offices are to be set up. One will be in the north (possibly at Leeds or Manchester), working for the North West, Merseyside and North Wales, North Eastern and Yorkshire areas. The second will be in the Midlands (possibly at Birmingham or Nottingham), working for the Midlands, East Midlands and South Wales areas. The third will be in London, working for the London, Eastern, South Eastern, Southern and South Western areas. With their flexible boundaries, these project offices will be able, by arrangement, to undertake projects in adjoining areas. They will be responsible for the construction of switching stations, new power stations, conventional as well as nuclear, and major extensions to existing stations.

Conference of Commonwealth Engineering Institutions

THE fourth meeting of the Conference of Engineering Institutions in the British Commonwealth is to be held in Australia from March 19 to April 1, 1958, and the delegates will thereafter make a visit to New Zealand between April 7 and 16. The Conference, it may be recalled, came into being in 1946, on the initiative of the Institutions of Civil, Mechanical and Electrical Engineers, the object being to consolidate the usefulness of the friendly relations which had long existed with kindred institutions in Commonwealth countries, and which had developed through much personal contact during the war years. The work of the Conference is mainly advisory ; it is complementary to that of the Conference of Engineering Societies of Western Europe and the U.S.A. and of the Pan-American Union of Engineers, there being liaison between the three organisations.

Working sessions of the forthcoming Conference of Engineering Institutions of the British Commonwealth will take place in Sydney, Melbourne and Canberra, and the delegates will also visit the Snowy Mountains hydro-electric scheme. The Institution of Engineers, Australia, is arranging for two special meetings to be held during the period of the Conference. At the first of these meetings, to take place on March 19 in Sydney, a paper entitled " Electrification of the Sydney-Lithgow Railway Line," will be read. The second meeting is to be held in Melbourne on March 25, when a paper on " The Development and Use of Water Resources in Victoria " is to be presented.

Charting the Seas

AN interesting lecture was delivered by Commander D. H. Macmillan, R.N.R., F.R.I.C.S., Hydrographic Surveyor to the Southampton Harbour Board, to members of the Southern Association of the Institution of Civil Engineers, who met under the chairmanship of Mr. W. E. C. Chamberlain, at Southampton University on Thursday evening, December 5. The lecturer dealt fully with both the historical and the romantic sides of the development of sea navigation and began by referring to the work of the priest-astronomer seamen of Egypt and the Middle East in pre-Christian times. After emphasising the importance of the precise measurement of time, in the determination of longitude and latitude, Commander Macmillan proceeded to outline the progress in the Middle Ages, the Rennaissance and the Reformation periods up to the present time. The outstanding work of Captain James Cook, probably the most skilled nautical astronomer of his day, was recalled, as were the researches made by Sir Isaac Newton.

Commander Macmillan went on to say that the institution of the office of Astronomer Royal and Hydrographer to the Navy, had " flowered to-day beyond all recognition." Great Britain had now charted the seas of the world, and the ship's chronometer and the communication of accurate astronomical time at any instant throughout the world, had brought horology to a refinement which made the determination of longitude a matter of precision to fractions of a second of arc. Arising out of the two world wars, the use of time bases giving micro-intervals for echo-sounding, asdic and radar devices, had revolutionised sea and air navigation, enabling sea and ocean terminals to be charted, sounded and administered, in such a manner that liners 1000ft and over in length, drawing 40ft of water, could come and go with clockwork regularity on their lawful occasions. The lecture was well illustrated by both drawings and lantern slides, and ended with the showing of a documentary film entitled " Precision Echo Sounding," which illustrates the work carried out in the Port of Southampton.

Nuclear Power in Southern Italy

AN international advisory panel appointed by the World Bank has arrived in Italy to select a site for a nuclear power station in the Lower Garigliano valley. British and American representatives are included on the panel, the British party consisting of Dr. J. M. Hill, United Kingdom Atomic Energy Authority, Industrial Group, Risley, and Mr. R. E. Newell, managing director, Wilton Works, Imperial Chemical Industries, Ltd. It is intended that this project will be carried through with World Bank support by Società Elettronucleare Nazionale (SENN), a subsidiary of the Italian utility holding company Finelettrica. The British and American advisers are at present working out proposals on the kind of reactor to be selected. The installed capacity is to be 150MW initially.

It is reported that the nuclear power programme is to be pressed forward with all possible speed, partly because the post-war expansion has already comprehended most of the available hydro resources and future increase will have to be provided by thermal power stations. The fossil fuel resources of Italy are restricted, however, making nuclear power particularly attractive in this case.

Effects of Heated Discharges on the Temperature of the Thames Estuary

By A. L. H. GAMESON, H. HALL and W. S. PREDDY*

No. II—(*Continued from page* 819, *December* 6)

A recent theory of the mixing and movement of the water of the Thames Estuary has been used to calculate the distribution of the heat which enters the estuary in heated discharges. By making simple assumptions about the rate of cooling of the water, which has not been directly measured, the difference between the temperature of the water during recent years and that during the last century, when there was little artificial heating, is calculated. The temperature records for the two periods was examined, and the calculated differences were found to agree well with the observed differences. It is shown that, within the normal range of temperature of the estuary, the increase of temperature which would be caused by an increased discharge of heat is independent of the existing temperature. The increases of temperature which would be caused by the entry of a unit amount of heat at various positions are calculated. The results provide an easy and rapid method of estimating the changes of temperature which would follow any alteration in the amount or position of the discharged heat.

Rate of Entry of Heat

IT is convenient to consider the various sources of heating under five headings, namely, power stations, industrial effluents, sewage effluents, fresh water discharges, and biochemical activity. Each of these will be examined briefly.

Power Stations.—Detailed information of heat discharged from power generating stations to the estuary during 1951–54 and for four earlier years was supplied by the Central Electricity Authority. The average quantity of heat lost to the river per kilowatt-hour generated is known for each station and so is the quantity of electricity produced. To these figures have been added the heat from the London Transport Executive's generating stations at Lots Road and East Greenwich, and from the generating plant of the Ford Motor Company at Dagenham. The average rate of discharge of heat from all these power stations during 1951–54 is estimated to have been 228×10^9 B.Th.U. per day, of which 73 per cent came from the five largest stations—the names of these stations

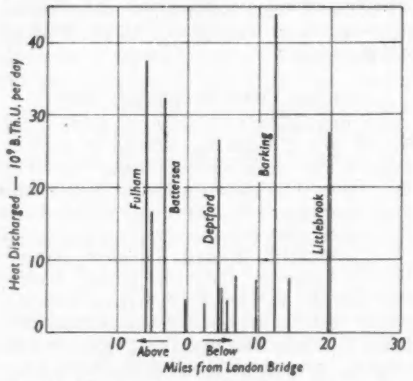

Fig. 7—Average rate of discharge of heat from Thames-side generating stations of the Central Electricity Authority during 1951-54

are given in Fig. 7, where the amounts contributed by the individual stations are shown. There is less power generated during the summer than in the winter and the relative quantities for the four quarters of the year, expressed as percentages of the mean value, are 114, 90, 85, and 111, respectively.

Industrial Effluents.—The chief sources of heat under this heading are gas works, paper mills and sugar refineries. The information has been obtained mainly from the North-Thames and South-Eastern Gas Boards, the Port of London Authority, various firms concerned, and from measurements and estimates made by the staff of the Water Pollution Research Laboratory. Few of the figures are very reliable, flows of condenser water are often known only approximately, and figures for the increase in temperature of effluent over influent may be in error by more than 20 per cent. For the largest sources of heat, efforts have been made to obtain information that is relatively more accurate than for the smaller discharges.

Where condenser water is taken from the river and returned to it after heating, the heat discharged is the product of the flow with the increase in temperature. Where process water is taken from wells, or from the water mains, the heat discharged is taken to be the product of the flow with the excess of the temperature of the effluent over that which would exist in the estuary, at the point of discharge, in the absence of all heated effluents.

The total heat discharged direct to the estuary from these industrial sources is estimated (from data relating mainly to 1952–53) to be $19{\cdot}4 \times 10^9$ B.Th.U. per day.

Sewage Effluents.—At the Northern Outfall Sewage Works of the London County Council the temperature of the effluent from the activated-sludge plant has been recorded each weekday since 1949. To obtain an indication of whether these temperatures are representative of the average temperature of the final mixed effluent, two recording thermometers were installed for one week by the Water Pollution Research Laboratory; no significant difference was found between the average temperature of the final effluent and the L.C.C.'s figures which, accordingly, have been used in calculating the heat discharged to the estuary. Taking the average of the products of the mean quarterly flow of effluent with the corresponding excess temperatures, the average rate of entry of heat during 1949–52 is found to be $14{\cdot}0 \times 10^9$ B.Th.U. per day.

Similar and even less accurate calculations were made for the Southern Outfall Works of the L.C.C., Mogden Purification Works, and the other sewage works discharging their effluents to the estuary. The final estimate for all the sewage effluents was 27×10^9 B.Th.U. per day—during the summer the rate is probably not more than 8 units, while in the winter it may be 40 units. It may be noted that perhaps a substantial proportion of this heat comes from industrial discharges to the sewers—the figure given above for industrial discharges applies only to discharges direct to the estuary.

Fresh Water Discharges.—The remaining sources of heated water are the Upper Thames (entering over Teddington Weir) and the numerous tributaries which discharge direct to the Thames estuary.

The heat entering at Teddington is the most uncertain quantity. If the flow is 4000 million gallons per day (m.g.d.)—a flow that was approximately the average during the first quarter of 1951—and there is an error of 1 deg. Cent. in either the observed or the basic temperature, the resulting error in the rate of entry of heat will be 72×10^9 B.Th.U. per day. Now it was stated above that the temperature at Teddington showed no significant increase from 1855–57 to 1915–21 and 1944–48, so that it is reasonable to assume that the heat entering over Teddington Weir was not great up to 1948. The average rate of discharge of heat from Kingston Power Station during 1951–54 was $10{\cdot}3 \times 10^9$ B.Th.U. per day, and, using the rate of loss of heat found later in this paper, it is found that, on the average, in travelling the mile from the power station to the weir at Teddington roughly 2 per cent of the heat is lost. No other appreciable sources of heat in this vicinity have been brought to notice and it will be assumed that the heat entering from the Upper Thames is 10×10^9 B.Th.U. per day.

Of the tributaries only the Wandle and Lea appear to contribute appreciable quantities of heat. The temperatures have been found from measurements made roughly once a week for a period of about two years from 1951 to 1953 by the Water Pollution Research Laboratory. The average contribution from the tributaries is estimated to be a further 10×10^9 B.Th.U. per day.

Biochemical Activity.—The oxidation of organic matter is an exothermic process. For compounds consisting solely of carbon, hydrogen and oxygen, the heat released in oxidation to carbon dioxide and water is about 10^5 calories for each gramme molecule of oxygen consumed. For instance, the average value for methane, methanol, ethanol, glucose, sucrose, benzene, acetone, and acetic acid is found to be 108,800 cal./mole of oxygen, with a standard deviation of less than 4000. For compounds containing nitrogen the variability is greater, but the mean value is roughly the same as before. It seems reasonable to suppose that the heat generated in the water of the estuary, as a result of the biochemical oxidation of organic matter, will be of the order of 10^5 calories for each gramme molecule of oxygen which enters through the surface, and for each gramme molecule which enters the estuary in solution (from the Upper Thames, the sea and other sources) and is subsequently used in oxidation. Converting this figure to more suitable units gives $0{\cdot}014 \times 10^9$ B.Th.U. per ton of oxygen.

From a consideration of the balance of oxygen in the estuary as a whole, it is found that the total rate of entry of oxygen is roughly 840 tons per day,[1] which indicates an average rate of heating of about 12×10^9 B.Th.U. per day.

Summary—The various estimates given above are summarised in Table III, where

TABLE III—*Average Rates of Entry of Heat to the Thames Estuary, in Units of* 10^9 *B.Th.U. per day*

Source of heat	Heat units	Percentage of total
Power stations	228	74½
Industrial effluents	19	6
Sewage effluents	27	9
Fresh water discharges	20	6½
Biochemical activity	12	4

* Water Pollution Research Laboratory, Stevenage.

the data from power stations are for 1951–54 and most of the others are for 1951–53. The total heat is 306×10^9 B.Th.U. per day. From this table it is seen that errors of, say, 20 per cent in the figures for the heat discharged from the smaller industrial discharges will have little effect on the accuracy of the work.

The heat from the fresh water discharges is attributable mainly to power stations which use the Upper Thames and River Wandle as sources of cooling water ; consequently over 75 per cent of the total heating of the estuary is due to power stations ; in the summer the proportion is more than 80 per cent.

Heating to be Considered in Subsequent Calculations.—In the calculations that follow, the excess of the observed temperature over the basic temperature is related to the input of heat to the estuary. Clearly the heating that was present when the temperature measurements used in calculating the basic temperature were made must be omitted from the sources of heat. The basic temperature data have come from various periods, and from a consideration of the changes that have occurred in the past century it was concluded that the most suitable method of approaching the problem was to use all the sources of heat given above, with the exception of the biochemical activity and some of the sewage effluents.

The degree of pollution of the Thames has changed during the past century ; it is probable that only about five of the fourteen heat units considered under biochemical activity should be included in the increased heating. Most of this heating will take place in the middle and lower reaches of the estuary, where its effect will be small; the quantity of heat involved being both small and uncertain, it has been omitted from the calculations.

Most of the sewage effluents have been neglected since their effects also are small and uncertain. The Mogden and Northern Outfall waters contain heated industrial wastes, and it is probably best to consider all the heat from Mogden and part of that from Northern Outfall as sources of heat that did not exist previously.

Rate of Exchange of Heat

The heat continually entering the estuary is dispersed by tidal mixing and displaced toward the sea by the flow of land water. Part of this heat is eventually lost by displacement through the seaward boundary of the estuary (wherever this may be defined), and the rest escapes to the air and to the sides and bed of the estuary. Before it is possible to relate the observed distribution of temperature to the rate of addition of heat it is necessary to examine the movement of the water and the mechanism by which the excess heat is lost.

Tidal Mixing.—Water discharged to the estuary is not only displaced seaward by the entry of water upstream, but is also carried to and fro over an average distance of 8 or 9 miles by the tide and is dispersed by the mixing of the water that results mainly from tidal action.

The displacement by the fresh water flow is readily calculated from data for the flow and the cross-sectional area of the estuary. The average excursion of the water along the estuary due to the tide is likewise found from tidal levels and surface widths. The dispersion by mixing, however, is not calculable from existing data, neither can it be found from any practicable experimental work.

However, if the amount of cooling that takes place in the course of, say, three tidal cycles is not too great, then a knowledge of the distribution of the water after this period should be sufficient for the present purpose—even if the distribution after a single tidal cycle, or shorter period, is unknown. (It may be of interest at this point to anticipate the results found later, by mentioning that the proportion of the excess heat lost from the estuary by cooling in a period of three tides is of the order of one-fifth.)

The dispersal of water during one tidal cycle remains unknown ; nevertheless it is possible to choose a form of representation which, although departing greatly from the true distribution during one tide, is likely to be in substantial agreement with the true dispersion after a period of surprisingly few tides. Fig. 8 illustrates this point for three

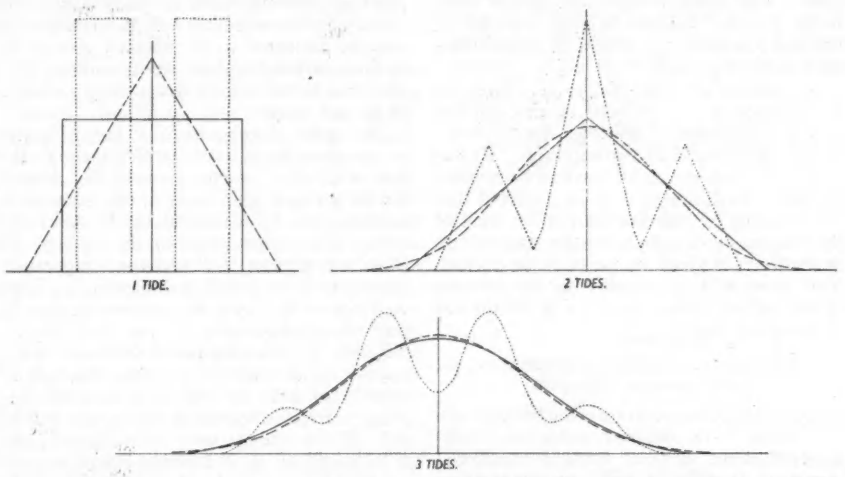

Fig. 8—Distribution of water after periods of one, two and three tides, using three different representations of symmetric mixing

different symmetrical distributions, one of which is deliberately chosen to represent a very improbable distribution. In the case of an estuary like that of the Thames—which widens out progressively toward the sea—the mixing will be asymmetric : the quantity of water passing through a cross-section will be greater the nearer the cross-section is to the sea, and by considering the exchange of water across a boundary from the neighbourhood of two sections equidistant from the boundary it is seen that a similar symmetric distribution at each section would lead to a net transfer of water across the boundary (in an upstream direction) by mixing alone.

The form of distribution that was eventually chosen to represent the mixing in the Thames Estuary was that shown in Fig. 9. A proportion P_1 of the water originally within the

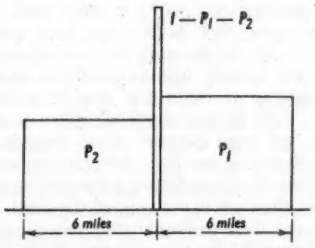

Fig. 9—Representation of mixing during one tidal cycle in the Thames Estuary

immediate vicinity of O is assumed, after a period of one tide, to be uniformly dispersed (in terms of amount per unit length) throughout a distance of 6 miles seaward of O—this is 2 or 3 miles less than the average tidal excursion. A proportion P_2 is similarly distributed upstream of O. The rest of the water returns to (or remains in) the immediate neighbourhood of O. This is a very flexible type of distribution with only two arbitrary constants to be determined. If the mixing is very intense it is to be expected that (P_1+P_2) will be almost equal to unity, so that little of the original water is left at O, while if the mixing is slight (P_1+P_2) will be small.

The magnitudes of the mixing proportions (P_1 and P_2), which vary from point to point in the estuary, may be found from two equations : one expressing the net transfer of water through any cross-section by mixing alone (this must be zero), and the other expressing the transfer of salt. The two equations have no algebraic solutions and the values of P_1 and P_2 have to be approached by successive approximations, by relaxation methods or by numerical integration. No details of the equations are given here as the subject has been dealt with at considerable length in an earlier publication.[5] In this work use was made of the extensive records of the flow of fresh water entering from the upper river at Teddington (provided by the Thames Conservancy) and of the salinity of the water of the estuary (supplied by the London County Council) ; details of the dimensions of the estuary were obtained from the Port of London Authority.

It may be mentioned that the values of P_1 and P_2 that were found appeared to be reasonable ; thus, nowhere did either value become negative, and nowhere did the sum of the two exceed 0·9 ; also P_1 was always greater than P_2 (as required by the asymmetry of mixing), and the maximum value of each was found a short distance below Gravesend near where the configuration of the estuary is rather irregular. No reliable figures could be obtained for the first 10 or 15 miles from the head of the estuary, owing to the very low salinities and to uncertainties in the amounts of salt coming from landward sources.

After the values of P_1 and P_2 had been evaluated the accuracy of this method of representing the mixing was checked by predicting the changes in salinity to be expected during periods when the flow was changing rapidly—given only the initial salinity distribution and the daily figures for the flow at Teddington. The distribution after two different periods of a fortnight, in one of which the flow was increasing and in the other decreasing, was predicted with gratifying accuracy. Calculation of the yearly average distribution of salinity during

1946 also showed satisfactory agreement with the observed values.

The method of using this theory of mixing in calculating the distribution of heated effluents discharged to the estuary will be considered in a later section. Perhaps it should be pointed out that the magnitudes of the mixing proportions are likely to be affected by variations in the tidal and fresh water flows ; no attempt has been made to obtain the values of P_1 and P_2 at spring tides and at neap tides, but since the results will only be applied to calculating average conditions over a period of three months, and since the salinity checks showed good agreement for a period of a fortnight, there is no reason to doubt the applicability of the values used. The effect of variations in the fresh water flow is likely to be slight—except in the first few miles for which the proportions have been calculated.

Mechanism of Heat Exchange.—Even in the absence of any artificial heating there is constant exchange of heat between the water of the estuary and its surroundings. Radiation, evaporation, conduction and convection all play a part, and it is to be expected that the amounts of heat transferred by each of these factors will alter when the temperature of the water is raised by the addition of heat. It is convenient to consider the temperature of the estuary at any point to be composed of two parts, thus

Water temperature = Basic temperature + Temperature Increment

where the basic temperature is the temperature that would have obtained under the conditions of slight artificial heating considered earlier in the paper, and the temperature increment is that part of the temperature that is attributable to the additional heat. It is also convenient to consider the heat content of the water to be similarly composed : the excess heat is then the increase in the heat content since the period to which the basic temperature refers. It is the relation between the excess temperature increment and the added heat that is now to be examined. First let us consider what exchanges of heat between the estuary and its surroundings are continually taking place and how the net exchange is likely to be altered by the addition of heat to the estuary.

It is presumed that the daytime heating of the water by the sun is responsible for the average water temperature being higher than the average air temperature (Fig. 3*a*). The heat received from the sun will not be affected by raising the water temperature a few degrees, but the radiation of heat from the estuary will be increased in the presence of heated discharges. The increase in the rate of loss of heat due to additional radiation is likely to be small compared with the increases due to other processes, and over the range of the few degrees by which the water has been heated the increased loss of heat from unit area of surface will be nearly proportional to the increase in temperature.

Evaporation from the water surface causes cooling, and the rate of evaporation depends on the temperature of the water, the temperature and relative humidity of the air in contact with it, the wind velocity, and the fetch of the wind.[8] The vapour pressure at 0 deg., 10 deg., 20 deg. and 30 deg. Cent. is 5mm, 9mm, 17mm and 32mm of mercury respectively ; over any range of 5 deg. Cent. the rate of change of vapour pressure with temperature is nearly linear, and so, if other conditions remain the same, it is probable that the increase in the rate of loss of heat by evaporative cooling is proportional to the increase in temperature, the constant of proportionality, however, increasing with rising basic temperature. As the meteorological factors which influence the rate of evaporation—particularly humidity and wind velocity—vary seasonally, and are therefore correlated with the basic temperature, it is impossible to estimate in what manner the constant of proportionality might vary.

The remainder of the heat losses will be by conduction to the sides and bed of the estuary, and by conduction and convection to the air. The increased loss to the bed due to the heat increment will be proportional to the temperature increment, to the thermal conductivity of the bed, and to the wetted perimeter. The increased loss to the air, over the temperature range that is involved, is likely to be nearly proportional to the temperature increment and to the width of the estuary ; the constant of proportionality may be expected to be affected greatly by surface turbulence and wind velocity, and may also depend on the relative temperatures of air and water.

The order of magnitude of the difference in the amounts of heat passing through the bed when the estuary is receiving heated discharges and when it is at the basic temperature can be estimated in the following way. If at some point in the estuary the basic temperature is T and the temperature increment is θ, and if at some point a long way below the bed the temperature is T_0 (and this temperature is not changed significantly by changing the temperature of the estuary by the amount θ), then the rate of transfer of heat through unit area at some point nearer to the bed of the estuary will be $b(T-T_0)$ if the estuary is unheated and $b(T+\theta-T_0)$ if it is heated—where b is a constant involving the thermal conductivity of the bed and the spatial arrangement of the points considered. The difference between these two rates is $b\theta$, which is equal to the rate of transfer of heat at the same point if the temperature of the estuary were $T+\theta$ and the temperature at the point a long way below the estuary were T. Consider next the rate of escape of heat from the estuary under these conditions if the bed of the estuary were only 1ft thick and if beyond that depth the temperature was maintained at the basic temperature. The thermal conductivity of the bed is unlikely to exceed four units of 10^{-3} cal./cm, deg. Cent., sec ; using this figure and a typical observed distribution of θ along the estuary it is found that the rate of loss of heat would be about one-third of the rate of addition of heat that produced the temperature rise. Now the total rate of transfer of heat through one isothermal surface below the estuary will be the same as for another, except for the heat that escapes from the banks to the air ; consequently, since the estuary is, for the most part, hundreds of feet wide, the heat passing through an isothermal surface about 2ft below the estuary will be nearly as great as that passing through the one at half that depth. Clearly, therefore, the effective depth of the bed must be very much greater than 1ft so that it is unlikely that the amount of the excess heat lost through the bed amounts to more than a few per cent of the total. At all events, it is probable that the change in the amount of heat transferred through the bed of the estuary due to heating of the estuary is proportional to the increase in temperature.

Taking all these things into account, it seems a reasonable hypothesis that if the temperature of the estuary water were increased by artificial heating, so that the temperature at any point were raised from T to $T+\theta$, then the rate of loss of the added heat, per unit area of the water surface, would be equal to $K\theta$. Both T and θ vary with position in the estuary (Fig. 6), and it is to be expected that K will vary both with position and with the basic temperature—quite apart from the short-term variations, which may be large, but which do not concern the present work.

If, after taking into account the ways in which heat is lost from the estuary, it had been concluded that the relation between the rate of addition of heat and the consequent rise in temperature was markedly non-linear then the whole argument which follows would be invalid. For instance, had the rate of transfer of heat been proportional to the square of the excess of the temperature over some particular temperature T_0, then at the basic temperature the rate of loss of heat would be $K(T-T_0)^2$, and when the temperature increment was θ would be $K(T+\theta-T_0)^2$; the difference between these two rates is $\theta[2(T-T_0)-\theta]$, a factor involving the basic temperature as well as the square of the temperature increment. On the other hand, if the relation is linear the two expressions become $K(T-T_0)$ and $K(T+\theta-T_0)$ respectively, and the difference between them is $K\theta$, which does not involve the basic temperature. This shows that if relation between temperature increment and heat loss is linear it does not matter if the basic temperature T refers to a time when there was some artificial heating, provided that the changes in heating that have produced the temperature increment are known ; in fact, θ need only represent the change in temperature distribution from one period of heating to another. For the present work, however, it was decided, after considering the data available for the observed temperature and the heat inputs, that the basic temperature should refer to conditions under which there was only a very small amount of artificial heating. Another consequence of a linear relation is that the effects of a number of discharges are additive—this would not be so if the rate of loss of heat was not proportional to the temperature increment.

The Exchange Coefficient, f.—For a given loss of heat the corresponding change in temperature is inversely proportional to the depth of the water ; the rate of change of temperature increment by a body of water may be written :

$$\frac{d\theta}{dt} = -\frac{f}{z}\theta \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where z is the mean depth (defined in this work as the cross-sectional area of the estuary at the instant when the water level is midway between average high and low water, divided by the surface width under the same conditions) ; the constant of proportionality f is seen from the equation to be defined as the rate of loss of temperature, per unit of temperature increment, from water of unit depth. It is also seen that this coefficient has the dimensions of a velocity ; in the present work it will be expressed in centimetres per hour‡ and referred to as the exchange coefficient (the same term as has been used for the exchange of oxygen between the air and water when measured in the same units).[1]

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(*To be continued*)

‡ The authors are aware of the mixed systems of units used in this paper. It is found convenient, however, to use ft., miles and B.Th.U., but deg. Cent. and cm per hour. For fresh water, 1cm per hour is equivalent to 2·04 B.Th.U. per deg. Fah., ft², hour.

Modern Tendencies in Arch Dam Design

By SERGE LELIAVSKY, Ph.D., M.I.C.E., M.Am.Soc.C.E.

No. I

It will be apparent to readers of this journal who have studied articles published from time to time, containing descriptions of arch dams in various countries, that many variations are possible. The author of this article points out that some of this variety results from differences of opinion amongst engineers, as to how the stresses in such dams should be calculated and as to how much reliance should be placed on model tests. He goes on to study whether any classification is possible and finally refers to certain aspects of dam design, such, for example, as spillways, the capacity or location of which may have an influence on the kind of dam adopted.

IT is an incontrovertible fact that, for some time past, there has been a general, almost subconscious but still uneasy feeling among more advanced circles of civil engineers about the problem of arch dam design. Were an analogy attempted between the gradual historical growth of this feeling, and the case history of a surgical abscess, one might possibly compare the publication of the symposium on the subject, in 1956, by the American Society of Civil Engineers, to the surgical operation consisting of the opening of such an abscess with a lancet! For a wide range of incompatible opinion was then made public, and it became possible to gauge the extent of the differences in the design principles, general approaches, techniques, methods and safety factors adopted, or followed, in different countries in connection with this particular kind of works.

Thus, whilst in other branches of civil engineering, for instance in the design of gravity dams, evolution in different parts of the world has tended to coalesce, the very opposite appears to have been the case with arch dams. In that field of design we observe a sort of centrifugal effect, in that, with every new achievement, the disparity in type seems to increase. To give a very obvious (though, maybe, superficial) illustration of the point which this discussion is intended to elucidate, attention is called to Fig. 1, con-

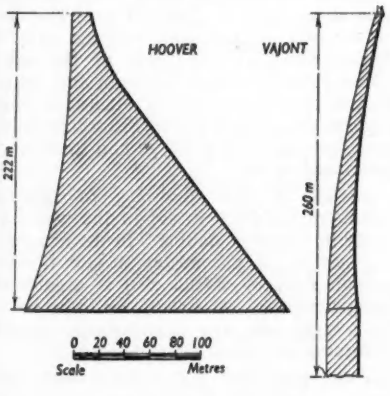


Fig. 1

trasting the profile of the classical American Boulder dam with that of a recent Italian project* of about the same height ; of course, many conditions are not the same, and therefore the difference cannot be attributed solely and entirely to the ideas of the respective designers ; but still !

The curious point about this design difference is that, in spite of so large a variety of structural types and methods used in different parts of the world, all these multitudinous works, although they do embody basically different safety factors and design assumptions, all nevertheless seem entirely safe, and perform perfectly well their various duties. In fact, none of them has so far collapsed, or shown any sign of serious trouble. Now, if this is so, why bother ? But such an attitude would, in the author's opinion, be altogether indefensible. For the only plausible explanation of so apparent a paradox could only be that, in certain cases, much too much superfluous material is being used by the designer, to satisfy some imaginary criterion which has no true physical counterpart in Nature. Every effort must therefore be made to give as much publicity to the papers of the symposium as possible, so as to broaden the outlook of the designer—to whatever country or nationality he may possibly belong.

Let us assume, as a starting point, that the completion of the Boulder or " Hoover " dam, in about 1935, and the subsequent publication of the voluminous and academically faultless report, referring thereto, mark the apogee of the popularity of the " trial-load " method, as embodied in that world-famous project. The essence of the method is, that the parts of the water load taken, respectively, by the horizontal, or arch, action of the dam (and thus transferred to the side banks of the valley), and the remaining part of the hydraulic pressure, which is absorbed by the vertical action, and thus conveyed to the foundation, are found " by trial " in such a manner that the calculated deflections are in both systems the same. This is an extremely laborious, well-known, and frequently used solution, which, in the period under review—i.e. in the middle 'thirties—became particularly popular, and was almost universally accepted, embodying, as it did, typically American influence. We shall return to further discussion of this method later, and give more information on its characteristic points. But for the present it will suffice to note that in applying this method, the designer makes no *a priori* assumption with respect to the relative importances of the two main actions, horizontal or vertical ; the extent of this importance being obtained at the end, as the numerical result of the computation.

Academically speaking, such an austere, impartial attitude may be (and very probably is) quite correct, but the designer may possibly object, because the maze of computation work and arithmetic to be performed in attempting to obtain a result by this method may completely obscure the issue. The project may then prove not very compatible with the main principle which it is supposed to incorporate. After all, an arch dam is an arch dam, and in this definition, the word " arch " is the guiding term ; and, therefore, to deal with such a work as if it were a sort of mixed structure is surely not always the right thing to do. In fact, the engineer is not an academic student, for he must not only investigate the stresses in a project but must also adjust its arrangement to its intended purpose. For instance, in the present case, the vertical, or cantilever, effect as calculated, may, and frequently does, cause inadmissible tensile stresses to appear at the base, which, in turn, forces the designer to widen out the base width until the profile—as in the case of the Boulder dam—begins to assume proportions similar to those of a gravity type dam.

There is, however, another way in which this trouble may under certain conditions be overcome. In that connection let us remember that in order to eliminate " fixation stresses " at the skewbacks of an arch bridge

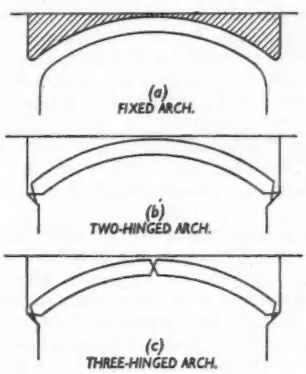


Fig. 2

(see Fig. 2 (*a*)) we may use the two-hinged (see Fig. 2 (*b*)) or the three-hinged (see Fig. 2 (*c*)) types (these hinges being either made permanent or only temporary). The part played by the hinges in a bridge is performed (at least partly) in the dam by the so-called " joints," and the relevant technique of using such joints, in its up-to-date stage, is possibly one of the most notable features of modern arch dam design. For, although vertical joints had been used even in the Boulder dam, in parallel and in full agreement with the " trial-load " method—the introduction, in the recent Italian dams, of the " perimetral " joint (see Figs. 3 and 4) is characteristic of an original concept, tending to reproduce the principle embodied in the

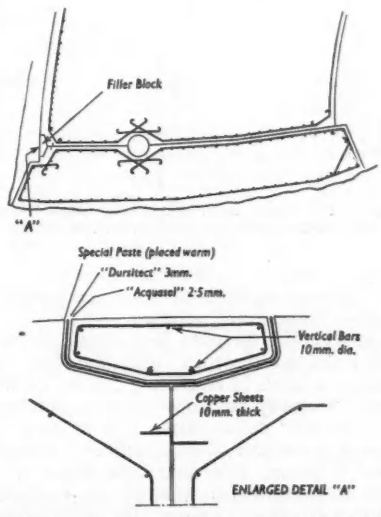


Fig. 3—Lumiei dam : details of the perimetral joint

* The Vajont dam, which is under construction whilst these lines are being written.

" hinged " arch bridge.[1] It is true that the joint was later grouted and also that a system of " trial-load " calculation, may have been evolved for this case as for an ordinary dam ; but since the device is essentially intended to magnify the importance of the horizontal

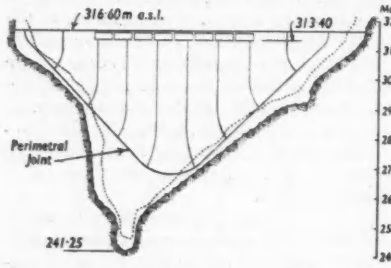


Fig. 4—Ponte Racli dam on the River Meduna : developed elevation along the middle fibre of the arches

arch effect, as against the vertical, cantilever action, the calculation by such a method is scarcely called for in this case. A very important point also is that secondary stresses are in this way reduced to a minimum. This example is meant to furnish evidence showing that the philosophy of the " trial-load " method has its limitations, and that there are other channels also along which the future evolution of arch-dam design may eventually develop.

The gradual realisation that there are other means of approach to the problem is almost certainly one of the causes of the uneasy feeling referred to in the opening paragraph ; and the credit for having demonstrated and popularised the point is largely due to the genius of the engineers of the Latin countries of Southern Europe, who have showed that design methods derived chiefly from the consideration of the horizontal action of the arch dam (in conjunction with an extensive use of specific model tests), yield a more

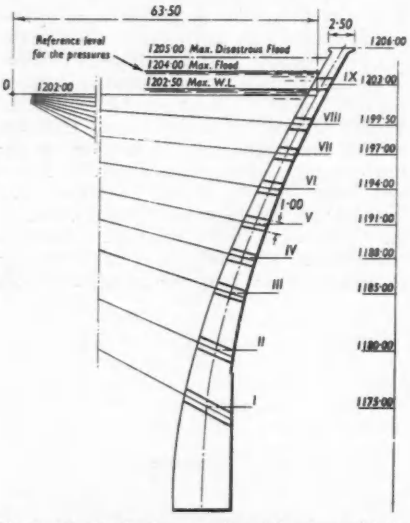


Fig. 5—Rio Freddo dam : section at the crown with the lines of the planes determining the check arches

elegant technique than those of a more-or-less passive application of the academically perfect " trial-load " solution.

In addition, the latest field results on dam deformation, recorded with the help of advanced kinds of measuring devices, do not seem to justify the time spent on elaborate " trial-load " calculations. For instance, in one of the papers of the American " Symposium," Messrs. Kimishima and Bonin say : " It is questionable whether the extensive time and effort required for a trial-load analysis is justifiable in view of the relative ' accuracy ' of this method as contrasted to some of the less laborious methods of calculation."[2] This statement is presented, in the publication referred to, as one of the twelve conclusions derived from systematic observations of the deformations of the lately built Kamischiba dam, in Japan, which were carried out during its construction and the subsequent filling operation of the reservoir. The engineers of the U.S.A. Bureau of Reclamation—the body chiefly responsible for the elaboration and application of the trial-load solution—say in reply : " Contrary to the apparent experience of the Laboratoria Nacional de Engenharia Civil,[3] Portugal, the Bureau of Reclamation has found that design of arch dams by trial load methods yields the most reliable results in less time and cost than by model tests. The question of reliability of results has heretofore been involved in the Bureau's experience, because the matter of model testing has not been as as conclusive by comparison with computed and observed results as has Portuguese and other European experience along these lines."[4]

Thus, both schools of thought uphold and maintain their respective basic positions. As matters stand now, one might possibly suggest a compromise conclusion, to the effect that the older method is better suited to the exigencies of the relatively wide valleys and canyons of the territory which is taken care of by the Bureau, whereas the philosophy of the newer solution originates in the deep and narrow gorges and clefts of the mountainous tracts of the Iberian and Apennine peninsulas and in Southern France. One point, however, needs to be made more clear. In fact, in order to avoid confusion, not too much stress should be laid on the purely geometrical interpretations of the terms " horizontal and vertical actions," as used in the foregoing discussion ; for the arch effect may also be held to apply in conjunction with sloping arches, as shown for instance, in Figs. 5 and 6,[5] which represent the Rio Freddo dam in Italy designed in this manner.[6] On the other hand, it would be an error to assume that the " trial-load " is the only method in which both actions are dealt with on an equal standing. For instance, the application of the elastic shell theory, according to Tölke's and other methods, (which also incorporate the same principle), has recently been gaining much in popularity. More on this point appears later.

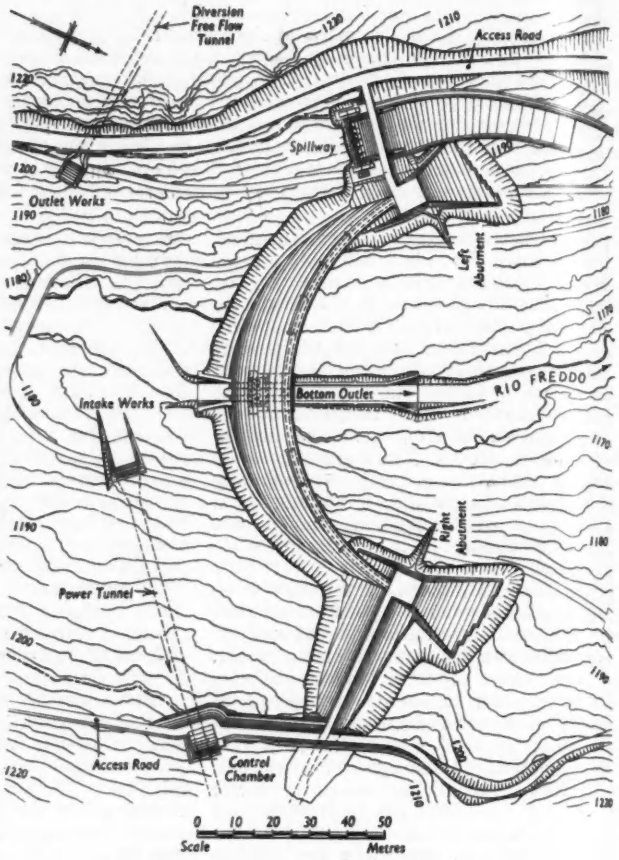


Fig. 6—Rio Freddo dam : general layout

Various Systems of Classification

In the usual pattern of a modern science, the primary objective of a classification is to help in systematising the study of the subject ; but in addition to that such a classification may also allow the beginner to obtain, from the start, a fairly correct idea of the scope of that particular discipline. This second object will be here our main consideration. Various indices can serve, as criteria, for classifying modern arch dam designs and the range of this variety is in itself an indication as to the very high standard the art of arch dam construction has now attained. For instance, arch dams may be classified according to : (*a*) the type of curvature ; (*b*) the order of magnitude of the thickness of the wall ; (*c*) the ratios of length to height and radius, as well as the constancy or otherwise of the angle or the radius ; (*d*) the historic period of construction ; (*e*) the type and function of joints, and so on.

(*a*) *Classification According to Type of Curvature.*—The curvature of the wall may either be single or double. In the first case, the surface of the upstream face (or the median surface) of the wall is capable of being developed on to a plane, whereas in the second case this is impossible without disrupting the continuity of the surface.

These two cases are schematically illustrated, respectively, in sketches (*a*) and (*b*) in Fig. 7. It will be observed that (*a*) is a true arch, whilst in (*b*) we have a part of a dome, or cupola. It is self-evident that (*a*) is the simpler and more usual form, whilst (*b*) is the more elaborate arrangement. In fact, in the earlier period of arch dam construction, this latter type was considered exceptional, but it is now frequently used. Curiously enough, it originated first in America (see section of " Six-Mile-Creek-Dam " in Fig. 8 reproduced from *Engineering Record*, 1904, page 469), but nowadays it is particularly popular in Italy and Portugal.

To give another example we may refer,

again, to Figs. 5 and 6, which show the Rio Freddo dam. According to Mr. Marcello, who is responsible for this work,[5] the vertical, i.e. cantilever, effect was altogether disregarded in calculating this dam. From the accumulated experience with recent model

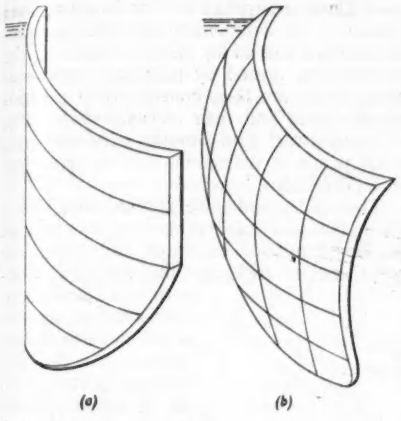


Fig. 7

studies, it was assumed for calculation purposes that the isostatic lines coincided with sloping planes (M. Coyne's " arcs plongeants "). As seen from Fig. 5, the slope of the eight imaginary arches chosen for the stress analysis, increased with the depth of water above them, in such a manner that their planes intersected in one single axis (except for the two upper arches which were taken to be horizontal). Another point deserving attention is that the upper part (about three-quarters of the height) of this dam transmits

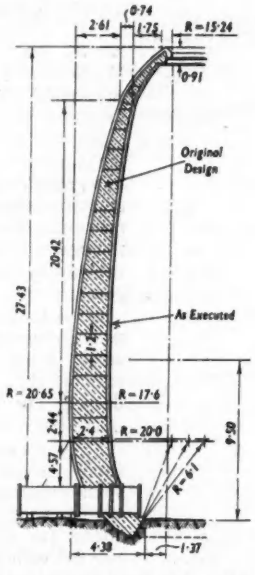


Fig. 8—Vertical section through Six Mile Creek dam

its thrust to concrete shoulders, or abutments (see Fig. 6), its lower part, only, abutting into virgin rock.

The calculation method applied in this case, if considered as a whole, is undoubtedly interesting and ingenious, and testifies to the uncommon personal intuition of its authors ; but the intriguing point is that a somewhat different solution is used at Isolato dam,[7] and still another one at Reno di Lei dam,[8] which, however, are both double curvature dams and are designed and built by the same author. The Isolato design is diagrammatically represented in Fig. 9,[9] which shows the sloping arches chosen in this case for stress analysis. The striking point is that this slope decreases with the depth below water surface, whereas the inverse was the case for the Rio Freddo design (see Fig. 5). That three different calculation methods are used for the seven assumed arches of the Isolato design, intensifies perhaps the effect of the arbitrary element of this particular stress analysis. In fact, the two lower arches are calculated according to Résal's solution, whilst for the three upper arches the usual method based on the elastic theory is applied ; with the proviso, however, that the deflections at the crown must be the same as for the top arch. And, finally, the two remaining, intermediate arches are assumed to be elastic and entirely free. The procedure is justified by the fact that the results, thus obtained, agree with model tests and observations of deformations on the prototype, but whether this is a general rule or just a coincidence, is not entirely certain, because of the arbitrary nature of the assumptions and their unknown effect on the result.

As regards Résal's method, this is one of the three semi-theoretical solutions, which seem to be particularly popular with some of the modern Italian dam builders ; the other two being respectively due to H. Ritter and A. Stucky. In order not to make this discussion too academic, some information will be given on Résal's method alone.[10] For Ritter's and Stucky's solutions the reader is referred to the original publications.[11]

There is one point deserving emphasis in connection with any form of statical analysis of arch dams, inclusive of experimental models, " trial-load " methods, and so many other solutions suggested for solving this difficult problem, namely, that almost all of them recognise and take into account the existence of tensile stresses in the material. In this, the arch dam designer digresses basically from the gravity-dam-design established tradition. In point of fact two alternative manners of dealing with tensile stresses are used : either the zone affected by such stresses is disregarded altogether and the external forces are equated to internal stresses in the compressed zone alone, or, alternatively, a very low permissible limit—for instance, 6 to 10 kg cm^{-2}, as against 60 kg cm^{-2} for compression—is allowed for the unit tensile stress, and both zones are, then supposed to be working in conjunction. In this connection, it should be remembered that the concrete used in these modern arch-dams is of an exceedingly high standard, the quality

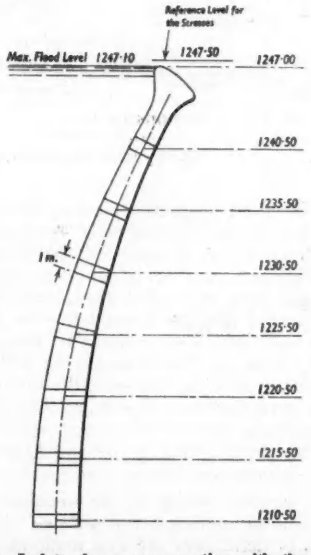


Fig. 9—Isolato dam : cross section with the traced planes normal to the medium fibre determining the check rings

of which is ensured by all the advanced methods of production control. As will be be seen from the following, Résal uses the first solution, i.e. he neglects the tensile zone altogether.

For convenience of formulation, he assumes the dam to be parabolic in plan (see Fig. 10), but shows that the results obtained on this assumption are a close approximation for other shapes also—for instance, the circular layout (so long as $b/l<\frac{1}{8}$). In general, the true alignment of the curve of the axis is of little importance for the results of the stress analysis, so long as the ratio b/e is less than 3·75 (for the meaning of symbols see figure).

For a uniform load q, the outline of the

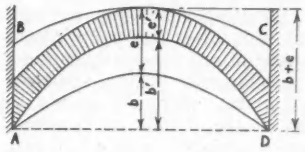


Fig. 10

compression zone (shaded in the drawing) is determined from the following equations :

Rise $b_1=3\cdot75(b+e)/4\cdot75$

Thickness $e_1=(b+e)/4\cdot75$.

The elastic deflection of the arch is then calculated taking into account the compressed material alone, whilst all the extended zone is entirely disregarded. In this manner Résal obtains for the deflection at the crown f the formula :

$$Ef=0\cdot209\,ql^4/(b+e).$$

In metric units the hydrostatic pressure at a depth y below the surface is $1000y$. Hence, $p+q=1000y$, in which p is the part of the pressure taken by cantilever action. For a uniform wall of constant height

$$p=\frac{Ee^3}{12}\times\frac{d^4f}{dy^4}.$$

Eliminating f from the two equations and writing

$$4\alpha^4=\frac{512\times12}{4\cdot75^3}\times\frac{(b+e)^3}{l^3}$$

we obtain

$$p=\frac{l^4}{4\alpha^4}\times\frac{d^4q}{dy^4}$$

which yields

$$q+\frac{l^4}{4\alpha^4}\times\frac{d^4q}{dy^4}=1000y.$$

Integrating,

$$q=1000y+Ae^z\cos z+Be^z\sin z+Ce^{-z}\cos z+De^{-z}\sin z$$

in which the variable z is equal to $\alpha y/l$ and A, B, C and D are the constants of integration.

This equation supplies the solution to Résal's problem, for it permits the determination for every level, of the load, q which is taken by the arch, and of the load

$$p=1000y-q$$

which is absorbed by the cantilever.

For this purpose, however, we must, first, find the values of the constants A to D. This is done as follows :—At the top of the dam, i.e. for $y=0$, the bending moment $EI\frac{d^2f}{dy^2}$ and the shear $EI\frac{d^3f}{dy^3}$ are both zero ; hence,

$$C=A-2B \text{ and } D=B.$$

On the other hand, at the base, if we assume

a fully effective "encastrement" at base level, both the linear and angular deflections are zero, which then yields the two other equations required for finding the constants. Once p and q are thus found, the calculation of bending moments and shears is done in the usual way. As the method calls for rather laborious arithmetic, Résal has produced a table which helps a designer to obtain the results. In addition to its primary objective the table yields also the following conclusions :—

(*a*) The "arching effect" in a straight dam ceases to be a consideration, if the length l is greater than two and a half times its height h.

(*b*) On the other hand, if l is less than one third h, the entire load is taken by this "arching effect."

The foregoing discussion referred to a uniform wall. For the more general case of a profile of any arbitrarily chosen shape, Résal recommends a trial-and-error procedure, which, after all, is but another version of the "trial-load" method, but employs simplified formulas of his own.

The reader should realise that Résal's method is given here as an example of a number of similar solutions proposed by various other authors, which can be used with more or less equal results, none of which has, however, been generally accepted or universally applied.

Reverting, now, to the last of the three quoted double-curvature dams, namely, the Reno di Lei, it will be observed that in this case the same author (i.e. Mr. Marcello) uses the trial-load method, subject, of course, to the same proviso, viz., that in all cases the numerical computation work is verified and checked, in Italy, by means of elastic model tests, which are so characteristic a feature of the modern arch-dam-design technique in Southern Europe. It should be realised, however, that a simple reference to the trial load method as such, does not suffice to define fully the procedure actually adopted in designing a dam, for there are several manners in which the basic principle of that method is capable of being used. In all cases we distribute arbitrarily the total load between the imaginary arches and the cantilevers, and repeat the process until the deflections of both systems are the same. This, indeed, is the general principle of the solution, applied in all cases ; but the question then arises, which of the various linear and angular elastic (or, possibly, plastic) deflections of the dam are to be used, as the true criterion, symptomatic of the correct division of the load.

The simplest of the various assumptions which are capable of being made in connection with this problem is to take one cantilever only—usually at the middle of the dam—and to consider radial movements at the points in which this cantilever intersects six to ten arches, selected at random at various levels, from the foundation to the crest of the dam. In a more accurate (and rather popular) version, several cantilevers (instead of only one) are selected, and radial movements are calculated for every point where such a cantilever meets one of the arches, referred to earlier. This solution seems to have been used on several European dams for a preliminary dimensioning of the work, but the Bureau of Reclamation experts are not fully satisfied with its precision ; in fact, according to their previous experience with model tests and observations on actual dams, the effect of the tangential shear and twist cannot be altogether disregarded, if results conforming with Nature are aimed at.

Mr. Fred A. Houk[12] describes the trial-load calculation method based on radial adjustments only, as the condensed solution, in contradistinction to the complete version, which takes into account tangential shear and twist, also, the effect of the latter two factors being supposed to be as follows.

(1) The maximum stresses, in both arch and cantilever elements, in most parts of the structure, are reduced.

(2) In the cantilever elements there is a tendency towards increased compression at the upstream face, especially in the lower elements.

(3) In the central part, reduction of both radial deflections and stresses is general.

(4) In dams with fillets, the stresses in adjacent arch elements are considerably increased.

In the Bureau's view, it follows that in spite of considerable additional computation work involved in the complete solution, this extra expense is fully justified. As a general conclusion, it may be suggested, that when the dam supports the effect of tangential stresses and undergoes less radial displacement, it is only natural that the normal stresses in the arches and cantilevers should be lower. It seems, however, that considering only the effect of hydrostatic pressure, the reductions of the maximum normal stresses through the introduction of the tangential shear and twist do not, as a rule, go beyond 30 per cent for maximum compression and tension.[13]

The general outline of the so-called complete solution is then as follows[14]:—"Adjustments of deflections are first made in radial directions. . . . Adjustments are next made in circumferential directions, then in angular directions. In circumferential adjustments, equal and opposite tangential shear loads are introduced by trial, to compensate for movements caused by radial loads, one set of loads being applied to the arch elements and the balancing set to the cantilever elements. In angular adjustments, equal and opposite twist loads are applied to arch and cantilever elements, to compensate for discrepancies in rotation caused by radial loads. Radial movements, caused by tangential shear and twist loads, are then considered in a radial readjustment and their effects considered in circumferential and angular readjustments, until resultant deflections are in agreement in all directions."

The reader will have realised that this is by no means a simple procedure, even though various kinds of diagrams and tables are produced to facilitate the required arithmetic; in addition to which, various secondary effects are usually introduced in this calculation, apart from the hydraulic forces and structural weights, such as :

(*a*) Application of equations of heat transfer theory, in order to find the worst location of isotherms which can produce the most dangerous stress pattern in the material.

(*b*) Shrinkage effects (unless such effects are dispensed with by properly designed and grouted temporary expansion joints).

(*c*) Rock movements, according to Voght theory or Boussinesque's peacock diagram.

(*d*) The cracking of the cantilevers at their base, which reduces the corresponding second moment, the width of the crack being determined by trial and error.

(*e*) Additional horizontal pressure, if prestress is produced by raising the pressure during the grouting operation of the joints.

(*f*) Earthquake forces, in areas where such forces may possibly be expected. These forces are to be considered both as regards the dam and, also, the water in the reservoir.

(*g*) Uplift.

(*h*) Additional pressures due to the presence of silt in the water and to ice.

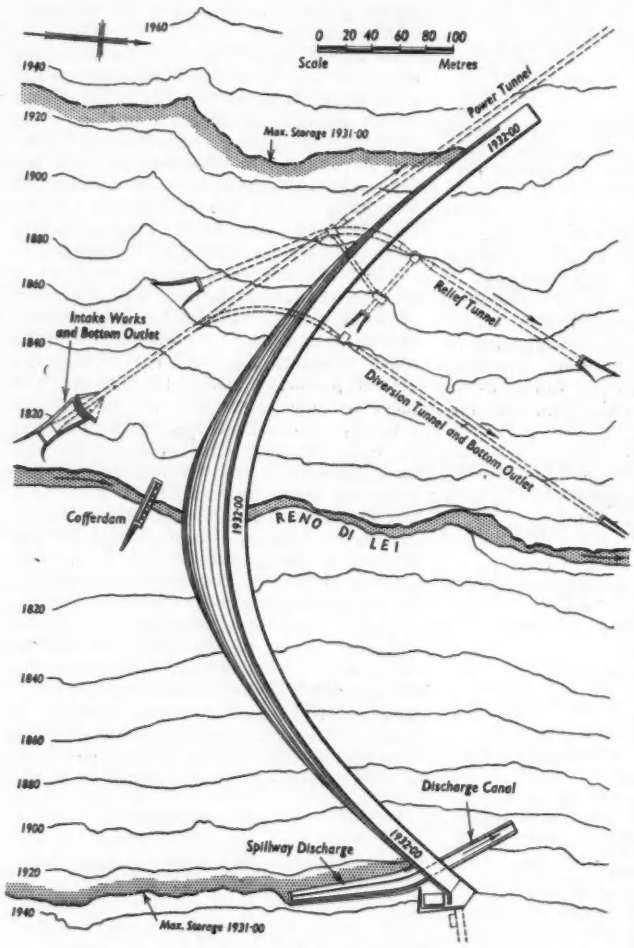


Fig. 11—Reno di Lei dam : general layout

Were this deluge of computation work to result automatically in a slenderer, more elegant, profile, there would be good reasons for using it in practice. But this is by no means so. Whilst in certain cases the condensed method has been used to verify stresses in relatively advanced, daring designs—such, for instance, as the Reno di Lei dam (see Figs. 11 and 12[15])—the complete trial-load method has more often led to the adoption of rather heavy, conservative designs, which, by reason of their bulky appearances, have sometimes been referred to as "arch gravity" dams. The author wishes to emphasise

that these remarks are by no means to be interpreted as adverse criticism of the method, which, as such, is a monument to the development of twentieth century engineering science. But this should not mean that other, shorter and more expedient methods—for instance, those based on the extensive use of models—cannot be used with much success and with all reasonable safety.

Reverting to the particular work under consideration, i.e. the Reno di Lei dam, there is one point about it, which deserves attention, viz. that instead of being circular in plan—as is the case with the majority of

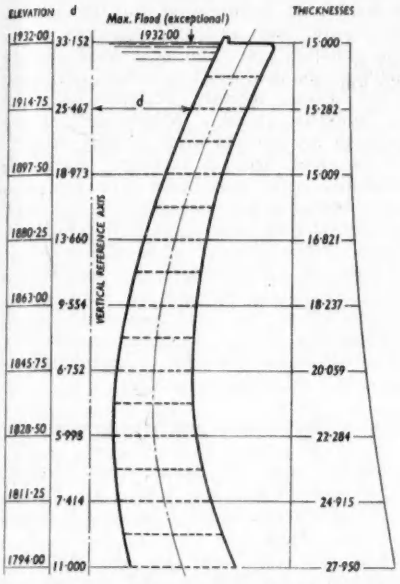


Fig. 12—Reno di Lei dam: set-out data section at crown

other arch dams—the horizontal alignment is in this case parabolic (see Fig. 11), in accordance with the simple equation

$$y^2 = Wx$$

where the parameter W is a variable function of the elevation. The *raison d'etre* of this equation is supposed to be that it yields a funicular polygon for the total forces (hydraulic) applied, and constitutes, therefore, the natural alignment which the axis of a dam subjected to these loads should follow, in order to reduce to a minimum the bending effect, in plan.

A still further development of the same basic idea, which may be quoted at this stage of the discussion, is incorporated in the method consisting in using a highly elastic model of the dam and subjecting it to an *inverse* pressure. Provided this pressure is raised to a sufficiently high intensity, we thus obtain the most advantageous shape of arch dam to be used for design purposes. This solution may justly be considered as a climax of modern technique.

It will be observed that we have produced in the foregoing discussion three examples of double-curvature dams, i.e. the Rio Freddo, the Isolato and the Reno di Lei. It is believed that they are amply sufficient to outline a graphic idea of the type, and we might have, therefore, been expected now, to give some examples of the other class, viz. the single curvature arch dam. This type is, however, of so simple a nature that specific examples are scarcely necessary to explain its principle. It will, therefore, suffice for our purpose to reproduce a diagram abstracted from the quoted paper of Mr. Carlo Semenza,[16] which contrasts ten Italian arch dams, built in the period since 1907, and in this manner yields a fairly clear picture of the difference between the two basic types (see Fig. 13).

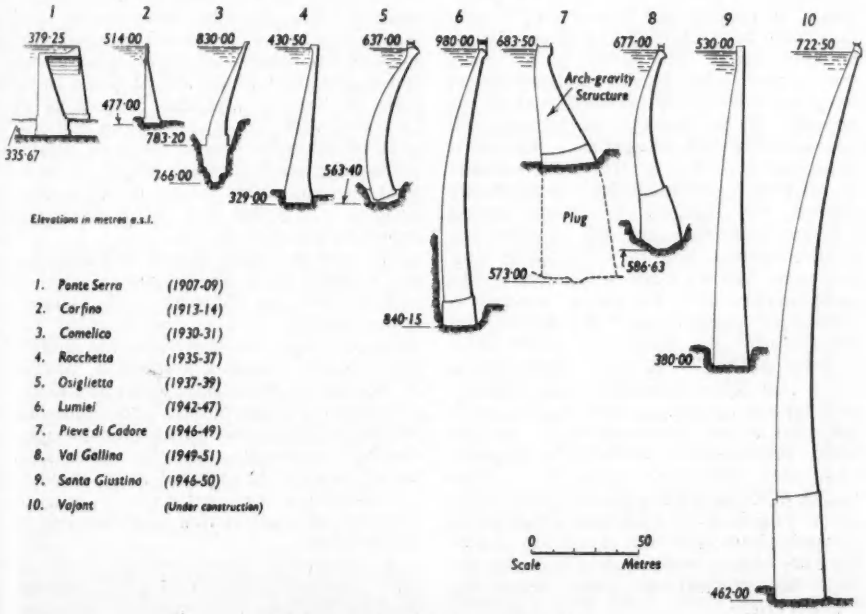


Fig. 13—Some typical arch dams in Italy

REFERENCES

[1] These figures are reproduced from Carlo Semenza, "Arch Dams: Development in Italy," *Journal of the Power Division, Proc. Am. Soc. Civ. Eng.*, June, 1956, paper 1017, page 1017–1, *et. seq.*

[2] H. Kimishima and C. C. Bonin, "Arch Dams: Measurements and Studies of Behaviour of Kamishiba Dam," *Journal of the Power Division, Proc. Am. Soc. Civ. Eng.*, February, 1957, paper 1182, page 1182–40. Similar views will be found in the publications of Portuguese authors.

[3] This is the competent department of the Government of Portugal, in charge of all studies in connection with dam projects and similar works.

[4] Fred A. Houk, Discussion of "Arch Dams: Design and Observation of Arch Dams in Portugual," by M. Rocha, *et al*, *Journal of the Power Division, Proc. Am. Soc. Civ. Eng.*, February, 1957, Disc. 1185, page 1185–12.

[5] From Claudio Marcello, "Arch Dams: Rio Freddo Dam, with Gravity Abutments and Cut-Offs," *Journal of the Power Division, Proc. Amer. Soc. C.E.*, June, 1956, paper 996, pages 3 and 9.

[6] The author of the concept of "arcs plongeants" is usually believed to be M. Coyne.

[7] Claudio Marcello, "Arch Dams: Isolato Double-Curvature Dam," *Journal of the Power Division, Proc. Amer. Soc. C.E.*, June, 1956, paper 995, page 1 and foll.

[8] Claudio Marcello, "Arch Dams: The Reno di Lei Double-Curvature Arch Dam," *Journal of the Power Division, Proc. Amer. Soc. C.E.*, June, 1956, paper 994, page 1 and foll.

[9] *Ibidem.*

[10] See *Annales des Ponts et Chaussees*, 1919, volume II; also, M. F. Bonnet, "Cours de Barrages," Paris, 1920, page 229, *et seq.*

[11] Hugo Ritter, "Berechnung der bogenformiger Staumauern," Thesis, Karlsruhe, 1913, and A. Stucky, "Etude sur les barrages arquées," These, *Bul. Techn. Suisse Romande*, 1922, and other articles in same review.

[12] *Ut supra.*

[13] M. Rocha *et al*, "Model Tests, Analytical Computation and Observation on Arch Dam," *Journal of Power Division, Amer. Soc. C.E.*, October, 1954, Discussion, page 1094–3.

[14] Westergaard, "Arch Dam Analysis by Trial-Load Simplified," *Engineering News-Record*, 106, 141–143, 1931.

[15] Abstracted from M. Marcello paper quoted in footnote [8].

[16] See footnote [1].

[17] Claudio Marcello, "Arch Dams: Santa Giustina Single-Curvature Arch Dam," *Journal of the Power Division, Proc. Amer. Soc. C.E.*, June, 1956, paper 992, pages 992–7. Note that Fig. 14 is abstracted from the same paper, pages 992–11.

(To be continued)

Framework of Transport

LAST Monday evening, the Henry Spurrier memorial lecture was delivered before the Institute of Transport by Major-General G. N. Russell, a vice-president of the Institute, and chairman of the management board of British Road Services. The lecture was entitled "Transport and the Common Weal," and the earlier sections of it included a survey of such matters as the highway system, railways and the changing traffic pattern.

Major-General Russell then proceeded to examine what he appropriately called the framework of transport; an inquiring mind, he suggested, must ask whether there was the right degree of competition in our transport system. The advantages of a competitive system were agreed upon, but, Major-General Russell urged, competition could be carried too far and the advantages bought at too high a price. On the one hand, he continued, the country was short of the capital resources it needed to refurbish industry and equip it to compete successfully in the export markets, and, on the other hand, we were embarking upon programmes of vast capital expenditure in road and rail. The consequences of capital being employed for the creation of duplicate facilities could be extremely serious; it should, instead, be directed into those channels where, with the aid of a wise commercial policy, the inherent advantages of each form of transport could be utilised to best advantage. The day might come, Major-General Russell observed, when the user was as little interested in the mode of transport used for the conveyance of his goods as he was when he posted a letter, but there was a long way to go in the development of our transport system before that high degree of confidence was engendered. Till then, it would be foolhardy to tamper irresponsibly with the user's freedom of choice.

The ideal framework, Major-General Russell said, would be so devised as to give us the best of all worlds—complementary forms of transport operating with a minimum of wasteful duplication and sufficient competition to produce maximum efficiency, co-operation where it improved the standard of facilities provided, and the whole system permeated with the traditions of a public service. But, the lecturer added, it must be remembered that, as engineering and science would never stand still, a static pattern would not suffice. Development plans must always be framed with a careful eye on the future; we must never again lag behind as we had done recently. Each form of transport should be used for the purpose for which it was economically suited, Major-General Russell thought, and, as a general rule, duplication should be avoided. If those two points were to be observed, he commented, it was obvious not only that available capital should be correctly invested, but that there should be a sound overall policy backing and guiding the investment. Lastly, Major-General Russell emphasised, each individual engaged must play a full and proper part in making a success of the industry, not as a sectarian in some particular part of it, but as what he really was—a "transport man."

LITERATURE

Book Reviews

The Structure of Steel. Third edition. By E. GREGORY and E. N. SIMONS. Odhams Press, Ltd., Long Acre, London. Price 18s.

THIS is a well-known book, previous editions having appeared in 1938 and 1942. Its sub-title is "A Simple Explanation for Students, Engineers and Buyers of Steel." The difficulties involved in attempting such a task are obvious and fundamental. The metallurgist who writes a specialist treatise for other metallurgists has no such problems to confront him, for he can assume that his readers will be familiar with his "language." The physical metallurgy of steel is a highly complex subject. Many readers of a book designed to simplify it have presumably little previous knowledge of it. Such a book must not be inordinately long, but must not simplify explanation by leaving out all the difficult parts. Many generalisations which are substantially correct are subject to a great number of qualifications, and it is not easy to deal with them in the space available. One may thus appear sometimes to be misleading, or, again, may be compelled to leave out some explanatory matter that could with advantage have been included. To satisfy all these conflicting requirements at the same time is very difficult. It is in the light of these considerations that the book should be read.

The chapter headings are as follows :— Constitution of iron-carbon alloys ; critical points ; crystalline forms ; impurities of steel ; alloy steels ; structure and mechanical characteristics ; microscopic structure ; principles of testing ; mechanical test methods ; non-mechanical test methods ; heat-treatment processes ; corrosion ; stainless steels ; and structural effects of mechanical working. An appendix includes a table relating the diameter of the Brinell hardness indentation to the hardness number and tensile strength of the steel, and a second table showing the equivalent hardness numbers by different scales. There is a nine-page glossary defining many of the terms used, and a classified bibliography listing more than eighty books and papers on various aspects of steel and steel working, this greatly facilitating the search for further information on any particular subject.

The book contains a great deal of information constituting it a profitable source of reference ; indeed, a book which has reached its third edition in nearly twenty years must necessarily be of such a quality. It could, however, be considerably improved without very much difficulty, for it shows sometimes an unfortunate looseness of expression, a lack of consistency in the sense in which terms are used, and apparent discrepancies between statements in one part of the book, and those on the same matter appearing elsewhere, which must be confusing to the reader. In a number of cases, also, the particular matter could be greatly clarified by a little further information, which is not supplied. The authors introduce terms, such as strength, ductility, brittleness and toughness, without properly defining them the first time they are used, and without including them in the glossary of terms at the end of the book. Toughness is first mentioned on page 33, where it is said that "Smaller grain size is, except in special circumstances (see page 34), always associated with increased toughness and strength." It is exasperating to find that the only further information on page 34 is that "fineness of grain may in certain instances be a bad rather than a good quality. Into this at the moment, however, we need not go." What the authors probably have in mind is that, in quenching high-carbon steel, fine austenite grain size is associated with shallow hardening and toughness, and coarse austenite grain size with deeper hardening and less toughness, but it would have been better to say this.

The authors say (page 54) that "tensile strength . . . cannot be co-existent with ductility" ; but also (page 84) that "for most engineering purposes a material having a relatively high tenacity but satisfactory ductility is aimed at." Mild steel, with a tensile strength of 30 tons per square inch and an elongation of 30 per cent before fracture, shows, of course, an excellent combination of strength and ductility. What the authors are trying to say on page 54 they have already said, more successfully, on page 1, that increase of strength and hardness in steel is at the expense of ductility and malleability. The term "ductility" does not appear in the index or the glossary of terms, and the only specific definition of it (page 54) is "the ability to be hammered or pressed out into shape without cracking." Surely this is malleability rather than ductility, although the two qualities are commonly found together. Ductility is specifically the quality possessed by materials showing, when loaded, considerable plastic deformation before fracture. The authors do say, indeed (page 70), that both elongation and reduction of area are "useful guides" to ductility. They are, of course, rather more than that, being, in fact, measures of it.

On page 67, where we are told that "the tougher the steel is the more force will be needed to break it," toughness is being regarded as strength—a common conception, but not one which should be endorsed in such a book. On page 95 it is said that "the energy required to break a test piece when subjected to a sudden blow . . . is an indication of the toughness of the material," toughness being here regarded as impact value or notch-toughness. The authors go on to say that "a precise definition of toughness cannot be given, but it may be considered as the opposite of brittleness," which (page 56) appears to be lack of ductility. All this is unnecessarily confusing. The authors should say that the term "toughness" is commonly applied very loosely, to denote several different qualities, as strength, ductility and notch-toughness, and they should be consistent in their own use of the term. The same applies to "brittleness," which is defined on page 39 as "the tendency to break down and disintegrate when mechanically worked." What is important to say is that brittle materials break suddenly, with little or no previous deformation, when subjected to an increasing load. In this sense, brittleness is certainly the opposite of ductility. Brittleness must not be regarded as lack of strength, for some brittle materials, as many kinds of cast iron, have a high tensile strength, but show no elongation before fracture. Again, some steels of high ductility show low notched-bar values, being thus "notch brittle."

In justice to the authors it should be said that these criticisms are those of a professional metallurgist, to whom any apparent error or omission can be painfully evident, and who may therefore be insufficiently appreciative of the real merits of the book. It is, of course, in many respects a valuable compilation, particularly when describing methods or processes rather than qualities. It contains a wealth of information on the ferritic, martensitic and austenitic stainless steels. The chapter on non-mechanical testing methods, many of which have been developed comparatively recently, describes all these in singular detail. Mechanical testing methods are covered in an equally comprehensive and detailed manner. Even the hardened critic could take little exception to the matter in these two chapters, and many will consider the book worth buying for these alone. Much more could be said in favour of the book. If, therefore, it is read with a little discrimination—such as many of its readers will be able to exercise—and a proper appreciation of the difficulties involved in writing it, one will be able to regard its purchase as a profitable investment.

Factory Organisation and Management. By T. H. BURNHAM, B.Sc., B.Com., A.M.I. Mech.E., and D. H. BRAMLEY, M.I.Mech.E. Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, London, W.C.2. Price 25s.

WHEN first this book by Mr. Burnham appeared as far back as 1929, we regarded it as "elementary and sketchy," and considered it only suitable for those who wanted to make a rapid and very preliminary survey of a very wide and diversified subject. Since then it has passed through several editions, each adding to its value and bringing it into line with modern practice ; indeed, it has become the standard work for those entering for the Associate Membership examination of the Institution of Mechanical Engineers, covering the field in a very satisfactory manner. Not long after the publication of the sixth edition, Mr. Burnham died, on May 14, 1952, and the task of revising and where necessary modifying has been undertaken by Mr. Bramley, who, in his own words, says he has "rewritten and amplified some of the basic ideas about management and organisation which will be found to be more in keeping with the suggestions of Lyndal Urwick" than in previous editions, as he considers the Urwick theory of organisation more nearly than any other fits in with what actually takes place in a modern business. It is felt that his modifications improve a useful work.

The seventh edition is now well arranged and is divided into eleven chapters, dealing in order with the following : the management function, the personnel function, the design function, the sales function, production facilities, planning production, control of production, purchasing, wages and incentives, control of expenditure, and estimating. We feel that the standard set for the manager, designer, estimator, and other officials, is higher than can be expected to be found in one individual, but perhaps it is wise to state the ideal with a view to stimulating to further effort.

A number of points raised seem to invite comment : for example, Mr. Bramley does not like the title of assistant manager, preferring that of assistant to manager, but

we feel that the former carries more weight, and the official in question should be prepared to take command on occasion, and be always ready to deputise. While we fully agree that F. W. Taylor's conception of functional organisation is unworkable, a modified form is not only workable, but in many cases commendable. A *sine qua non*, however, is that functional chiefs should do everything through the shop foreman, and only deal directly with an operator on bench or machine when asked to do so by the shop foreman. Most managers would do well carefully to consider the definite statement that "a good organisation is not impaired by the absence of particular individuals." Many managers seem to imagine that it is good to be missed. In dealing with the design function, we should like to see the suggestion made that when a design for a new product is finalised, it should be passed to the works manager for him to confirm that there are no insuperable manufacturing difficulties, and even if possible go further and make suggestions as to any slight modifications which might reduce the cost of manufacture. When dealing with the sales function the important question is raised as to whether it is essential in an engineering works for the sales manager to be a technician, and the authors maintain an impartial attitude, but generally speaking, it must be desirable, if not essential, for the sales manager to be able to deal with a potential customer on his own ground, and cases could be cited where the substitution of a qualified engineer for a non-professional man, has resulted in increased sales. It would be impossible to delve too deeply into the subject of control of expenditure and the part played by the cost accountant, but a very fair outline of his activities has been given, sufficient for the student to appreciate the importance, indeed necessity, for a good system to be operating, and one that can submit costs soon enough to be of practical value to the manager. We confess we do not like the term "reconciliation" as between the financial and the cost accounts, suggesting, as it does, a measure of hostility between them; the two accounts should be "interlocked." We should like to be told to whom the cost accountant should report, indeed, under whose control Mr. Bramley would place the respective heads of departments; for example, should not final inspection be entirely divorced from works management? When studying the planning of production we meet with the unusual term of "profitless prosperity," and we are shown that over-expansion of a business had led to its ultimate ruin. Certainly cost accounting has proved how profits may sometimes be increased by entirely closing a branch of the establishment. Allusion is made to the difficulties incident to the manufacture of goods for which there is only a seasonal demand, which calls to mind the case of a manufacturer of sausages, who, finding the demand fell considerably in the summer, took also to the manufacture of ice-cream where seasonal demands were the opposite. The various forms of incentive to increased production are fairly described, but in considering straight piecework it would be well to stress that there must never be any cutting of prices, except where a genuine change of method has been introduced. On page 157 we are told that "the operating costs of trucks may be represented as shown in Fig. 20," presumably this should read "Fig. 40."

The foregoing remarks are in no way intended to imply adverse criticism, but rather for Mr. Bramley to take into account, if and when a further edition is in mind. We are somewhat surprised that the word "automation" does not find a place in an up-to-date book on organisation, and one that as revised and amplified is eminently suited to the needs of a student who is desirous of passing examinations in engineering economics, or industrial administration, but it can further be recommended to engineering managers who will find much in its pages of interest as giving food for constructive thought.

Quality Control and Statistical Methods. By EDWARD M. SCHROCK. Second edition. Reinhold Publishing Corporation, New York. (Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2.) Price 54s.

THE preface to the first edition states that "The purpose of this book is to present as clearly as possible, as briefly as practicable, and yet adequately, the most generally useful modern techniques of quality control and statistical methods as applied to industrial problems of product quality. It is intended for those who are new to the field." The method adopted by the author has been, first, to give a brief history of the development of modern quality control and continue with a section on preliminary organising work. He then, after some warnings on kinds of error in data, deals with elementary statistical conceptions, particularly relating to measurements of dispersion, the normal distribution, &c., and proceeds to the quality control chart for variables, with particular reference to application and interpretation. There then follows a much longer section on control charts for attributes, one on quality control for limit gauging, using the method originally devised by D. J. Desmond in this country, a chapter on control limits and specification, another on the binomial and Poisson distributions, and, finally, sections on some rapid approximate tests of significance, acceptance sampling, Dodge Romig and others, and sequential and correlation.

This book is correct in its statistical theory and it gives practical advice. It is, however, relatively short, 240 pages, to cover a rather wide field, and one feels that while the technician who is interested in quality control may acquire useful information from the book, he must, if he is to be really well informed, seek also a more comprehensive publication. Within these limits, the book can be recommended to the engineer who wishes to gain some knowledge of quality control and statistical sampling.

Books Received

Thermodynamics of Heat-Power Systems. By F. W. Hutchinson. Academic Books, Ltd., 129, Queensway, London, W.2. Price 68s.

Irrigation and Hydraulic Design. Volume 2. By S. Leliavsky. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 294s.

Electro-Magnetism and Relativity. By E. G. Cullwick. Longmans, Green and Co., Ltd., 6 and 7, Clifford Street, London, W.1. Price 63s.

The Works of Pier Luigi Nervi. Translated by Ernst Priefert. The Architectural Press, 9–13, Queen Anne's Gate, London, S.W.1. Price 56s.

Engineering Progress and the Oil Industry. Edited by George Sell. Institute of Petroleum, 61, New Cavendish Street, London, W.1. Price 30s.

Basic Automatic Control Theory. By Gordon J. Murphy. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 67s. 6d.

Reinforced Concrete. Third edition. By J. McHardy Young. Crosby Lockwood and Son, Ltd., 26, Old Brompton Road, London, S.W.7. Price 12s. 6d.

Reports on Progress in Physics. Volume 20, 1957. Edited by A. C. Stickland. The Physical Society, 1, Lowther Gardens, Prince Consort Road, London, S.W.7. Price 63s.

Technical Reports

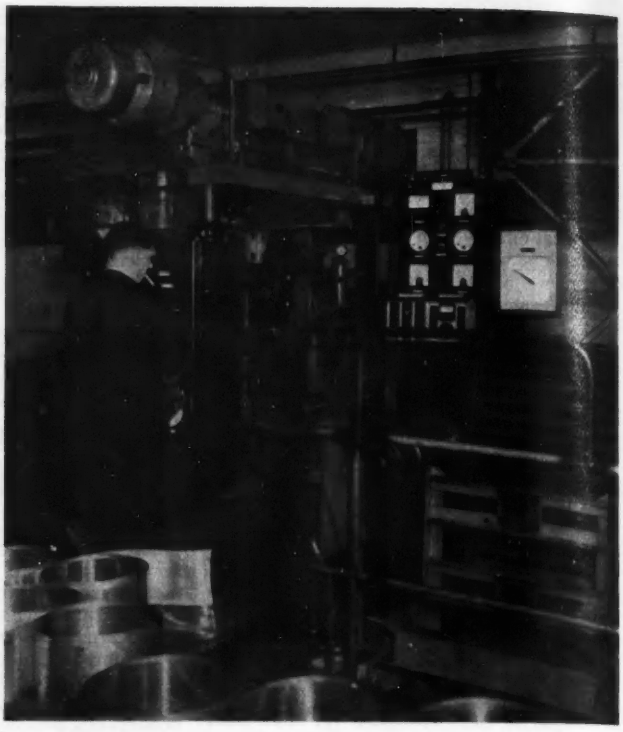
The Effects of Cylindrical End Rings on the Distribution of Surge Voltages in Transformer Windings (Ref. S/T69). By E. L. White, B.Sc.(Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 12s., postage 4d.—The distribution of surge voltages in transformer windings has been treated in a number of earlier reports, namely, Refs. S/T2, S/T4, S/T19 and S/T34, all of which are incorporated in *Surge Phenomena*, Ref. S/T35. Later reports on the same general subject are Refs. S/T48 and S/T55. The present report describes an experimental investigation of the modification in surge voltage distribution which is produced by conducting cylinders connected to the end terminal and arranged to shield a portion of the winding at the line end. This report gives an account of an experimental investigation of the effects of cylindrical end rings on the distribution of surge voltages in a transformer winding. The investigation was made to supplement the data already obtained on the effects of reinforced end turn insulation, which is given in Ref. S/T34. Measurements were made on an experimental transformer fitted with cross-over coils, and the effects of three simple arrangements of cylindrical end rings mounted coaxially with the windings were examined in some detail.

Bandstrassen im Baubetrieb ein Leitfaden für die Praxis. By H. Eckert. Springer-Verlag, Reichpietschufer 20, Berlin, W.35. Price DM.37.50.—It is the purpose of Dr.-Ing. Eckert's book to inform the building industry about the use of belt conveyors which, e.g. in opencast mining, have had a large measure of success, and to give basic data for determining the cost of conveyor installations. This last, it is thought, will be particularly welcome, since firms are usually allowed only a minimum of time in which to submit tenders. In the first portion of the book are discussed the various kinds of conveyor belts, their supports and other equipment which are available to the user. The designs of belts include normal and steep-gradient versions as well as those used in combination with a covering belt. The chapter also discusses the available jointing methods. Support structures, including rollers, driving mechanisms and motors, tensioners and adjusters are discussed in the second chapter. This is followed by a description of electric and diesel-electric drives, and a number of ancillary devices and installations. Part II gives data for the size and power required for any given output, and provides information on first cost and maintenance and operating expenditure.

Barèmes et Abaques de Resistance des Principales Sections Utilisées en Construction Métallique. By B. Macquart. Centre Belgo - Luxembourgeois d'Information de l'Acier, 47, rue Montoyer, Brussels. Price B.fr. 200.—In compiling this set of tables and nomograms, giving the resistance of the most frequently used steel sections under compression (or tension) loads, the author bases his work on the design rules laid down in January, 1956, by the French Secretary of State for Reconstruction and Housing. These rules, the "Règles CM1956," provide for checking the strength of a member under these conditions of loading. Each section is shown on the graphs with both axes of inertia (marked plus and minus). The tables are arranged so that it is easy to obtain the working stress in relation to the load, the permissible loads as a function of the maximum stress and the reduced areas in relation to the length. If it is necessary to work to rules other than those mentioned, this can readily be done, and for this purpose are appended the regulations of the French Air Ministry (December, 1951), the German DIN.4114 (1940), Belgian A.B.S. (1937), British (1942), Italian and United States (1949) rules. The introduction is in French, English, German and Portuguese.

Testing of H.T. Stabilizers (Ref. V/T129). By S. J. Zgorski. The British Electrical and Allied Industries Research Association, Thorncroft Manor, Dorking Road, Leatherhead, Surrey. Price 15s., postage 6d.—The existing literature on stabilised power supplies contains very little on the methods of testing such supplies. The main difficulties of accurate measurement of stabilisation ratio or output impedance are listed. The report describes a test set which largely overcomes the difficulties and facilitates quick measurements of the output impedance and stabilisation ratio at direct current and over a frequency range. The unit utilises normal laboratory auxiliary equipment such as oscillator, valve voltmeter and microammeter. The set was designed to provide an easy means for the initial testing and subsequent routine checks of a large number of stabilisers used in the E.R.A. network analyser. The stabilisers are supplied from a central d.c. plant. The set, therefore, was designed for stabilisers which have not their own rectifying circuits, but can easily be adopted for testing self-contained stabilised power supplies.

Strip Mill with Automatic Gauge Control

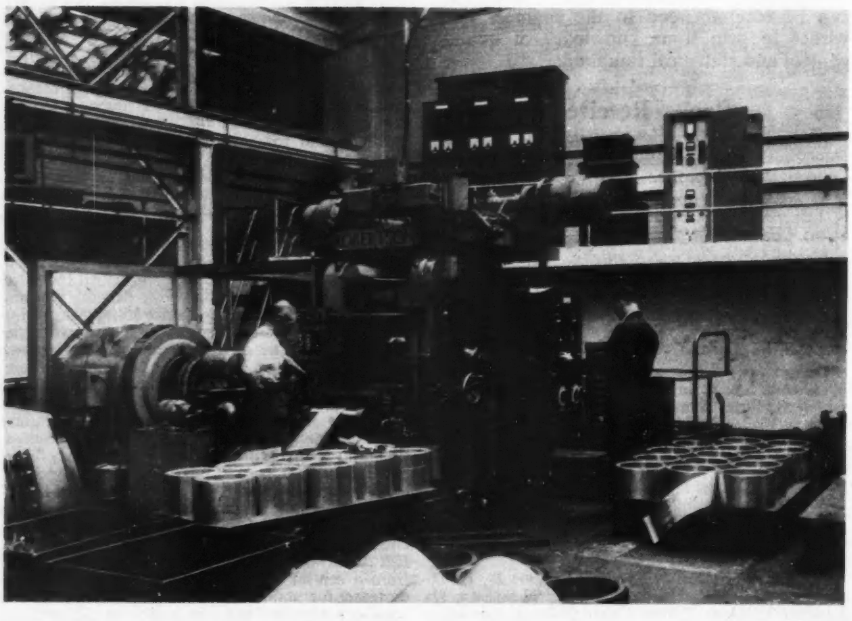


An automatic gauge control equipment, employing Strontium 90 as a radioactive source in a measuring head, has been fitted to a cold brass strip rolling mill by the Baldwin Instrument Company, Ltd. It is designed to maintain a constant check on strip thickness on the outgoing side of the mill and automatically adjusts the roll screwdown to correct variations. This mill, built by W. H. A. Robertson and Co., Ltd., can be seen here. It is used at the Birmingham works of D. F. Tayler and Co., Ltd., for finishing brass strip up to 15in wide and down to 0·004in thick, at rolling speeds up to 500ft per minute.

A COLD brass strip rolling mill which was built by W. H. A. Robertson and Co., Ltd., of Bedford, and installed in the Birmingham works of D. F. Tayler and Co., Ltd., two years ago, has recently been fitted with a new automatic gauge control equipment developed by the Baldwin Instrument Company, Ltd., Dartford, Kent. The mill is used for finishing brass strip up to 15in wide and down to 0·004in thick, at rolling speeds of up to 500ft per minute. It is of four-high design with 5¼in diameter by 18in face width rolls supported by 15in diameter rolls. Non-reversing operation is practised, with batch rolling of coils of brass strip of up to 5 cwt.

The general construction of the mill installation and control equipment can be seen in the photographs we reproduce. All four rolls are mounted on roller bearings contained in cast steel chocks, the mill housings being of cast steel construction. The roll stand is supported on a heavy cast iron bed incorporating a catch tray and return piping to the main tank of the roll coolant system. This system provides for the rolls to be cooled by spraying with soluble oil at up to 25 gallons a minute. The work rolls are driven through balanced universal spindles and a combined reduction gearbox and pinion housings by a 100 h.p., d.c. motor.

An adequate degree of counterbalance is applied to both the work and the support rolls to ensure that there is no slip between them, or backlash in the roll positioning gear during light running conditions. Roll gap adjustments are made by a twin-motor screwdown gear driven by two 4 h.p. motors, which are connected through a magnetic clutch and drive to the mill screws through worm reduction gearing. The two screws can be adjusted either simultaneously or individually, and the roll settings for each screw are displayed on the operator's panel by indicators coupled to Selsyn transmitters in the screwdown mechanism. A load cell located under each screw gives a continuous measurement of the rolling load on the mill. Loads are shown on a large dial indicator which incorporates a microswitch that can be set to trip at any predetermined value of the rolling load. This safety device can be used to reverse the screwdown mechanism in order to prevent overloading of the mill.



Ingoing side of the rolling mill. The electronic unit can be seen on the gallery above the mill in the background

On the incoming side of the mill, coils are placed in an uncoiling box which is fitted with quickly adjustable side guides to provide for various widths of material. From this box strip is fed over an idle deflector roll on the combined feed table and sticker unit. Adjustable side guides on the table ensure that the strip is accurately guided laterally into the bite of the work rolls, and a pneumatically-operated wiper press lined with hard felt, not only removes any dust from both surfaces of the strip but also allows a useful degree of back tension to be applied. Rolling oil is fed to the hard felt wiper from a separate rolling oil tank and pump installation and is applied evenly over the surface of the strip. The feed table assembly is mounted on slides carried in the roll housings, and as soon as the strip is clamped in the wiper press the table is thrust forward by an air cylinder to force the leading edge of the strip between the work rolls. With this design of feed table handling time is reduced to a minimum between rolling cycles.

On the outgoing side of the mill the roll housings are spanned by an outlet table carrying strippers which extend right up to the bottom work roll. Strip issuing from the mill travels along the stripper plate, past the continuous thickness gauge and over an idle deflector roll to be received by the recoiling reel. This collapsible design recoiling reel is 12in nominal diameter and is driven by a separate 15 h.p. d.c. motor. An important point in the design of this reel is that the

gaps between its segments are so small that no marking of thin gauge strip occurs and the practice of coiling the strip on to sleeves has not proved necessary. The reel is equipped with a brake and an air-operated coil stripper mechanism which pushes the completed coil off the collapsed reel and on to a receiving carriage, either for return to the ingoing side of the mill for further reduction, or to the annealing furnace. Rapid and efficient starting of the strip on to the reel is effected by a horizontal traversing belt wrapper which is moved pneumatically into its operative position and withdrawn when sufficient laps of strip have been started on the reel to allow coiling tension to be held.

The coil feed and recoiling mechanisms have been designed with a view to reducing handling time on the mill to a minimum, and it is stated that in practice the average elapsed time between coils is about 15 seconds. The mill is operated by a crew of two men, a roller whose duties include coil banding and a helper who feeds the mill. All the air cylinder control valves in the feeding and recoiling equipment are solenoid operated from push-button stations carefully sited within easy reach of the operators.

A complete roller conveyor system, which is provided to return coils by gravity from the outlet to the ingoing side of the mill for further cold reduction, can accommodate up to thirty coils. It is situated on the drive side of the mill so that the opposite operating and roll changing side is left clear. A combined coil elevator and downender is operated automatically by the coils during their passage through the conveyor system.

Detachable rails are provided for withdrawing either the work rolls only or the complete roll assembly. The desirability of roll changing with a minimum loss of time has influenced the design of the ingoing feed table and outlet stripper table. The feed table and roll coolant sprays are withdrawn together clear of the roll assembly by the simple operation of the sticker cylinder. The surface of the outlet stripper table consists of a number of parallel slats which can be quickly pivoted about a fulcrum to a vertical position where they are clear of the roll assembly.

The electrical equipment for the mill was supplied by the English Electric Company, Ltd. The 100 h.p. d.c. mill motor has a speed range of 500/1000 r.p.m. and the coiler motor is rated at 15 h.p. with a shunt speed range of 500/1000 r.p.m. The mill motor speed is adjustable from zero to 500 r.p.m. by generator voltage control, the motor field being at full strength. The motor field has a range of 2 : 1, thus extending the speed range up to 1000 r.p.m. to give the required maximum rolling speed of 500ft per minute. The reel motor is separately supplied from a generator, the output of which is proportionate to mill speed and is compensated for voltage drop and inertia. The tension applied to the strip is automatically regulated by field control of the reel motor. The control circuits and machine fields are supplied from a constant voltage exciter incorporated in a motor generator set which incorporates the mill and reel generators and is driven by a 165 h.p. 400V slipring induction motor.

As can be seen from our illustrations, the mill operating controls are grouped in a cabinet hinged from the mill housing on the outlet side, from where the mill operator can watch the various indicators and strip with the controls placed naturally to hand.

Automatic Gauge Control Equipment

The automatic gauge control equipment fitted in the mill by the Baldwin Instrument Company, Ltd., maintains a constant check on the thickness of the strip passing from the rolls, and automatically corrects variations exceeding ±0·0003in through adjustment of the screwdown mechanism. This design of nucleonic thickness gauge employs the Bremsstrahlung radiation produced by a beta-emitting radioactive source, Strontium 90. Its principle is similar to that of the gamma-ray thickness gauge described in our issue of April 12 last. Radiation from the source holder, which can clearly be seen in one of our illustrations, is directed at a detector with the moving metal strip passing in between the two. The radiation, in passing through the metal, is weakened by an amount depending on the strip thickness. The detector and its associated amplifier measure the intensity of radiation penetrating the strip and expresses it in units of thickness. This in turn is converted into a reading in terms of deviation from a preset specified thickness.

When deviation exceeds a certain preset thickness in either a positive or negative direction, a discriminator causes relays to operate which in turn cause the mill screwdown motors to operate. The control action has two discrete functions, the first to apply small intermittent corrections to the screwdown when the material exceeds tolerance by a small amount, and the second to apply a radical and continuous correction when tolerance is exceeded by a larger amount. There are three tolerance zones which are normally set as follows :

Dead zone (±0·0003in). Whilst material remains within this tolerance, no corrective action is taken.

Inner control zone (±0·0003in to ±0·0005in). Intermittent corrective action is taken.

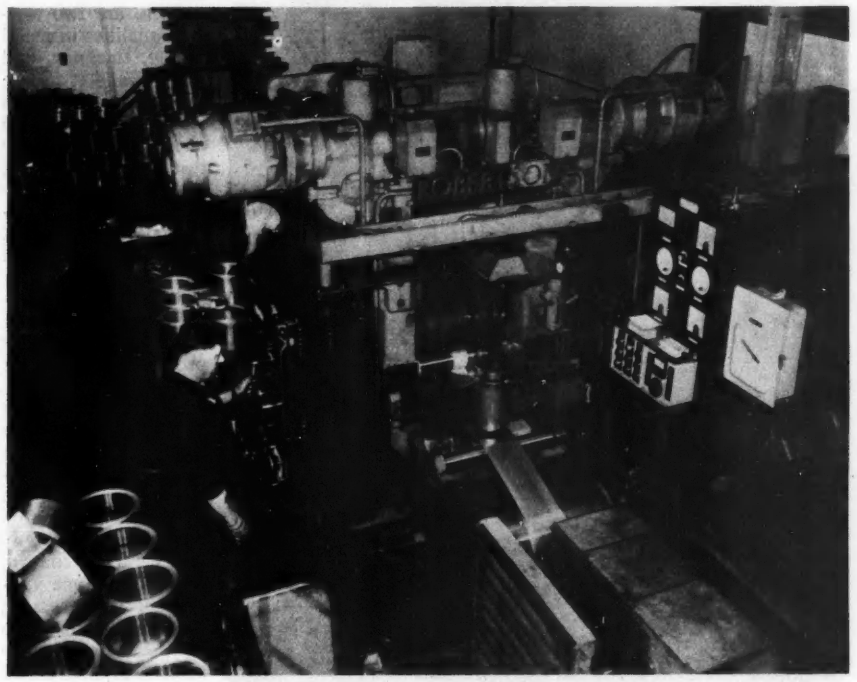
Outer control zone (±0·005in and over). Continuous corrective action is taken.

As metal rolling is an intrinsically intermittent process, there are regular intervals during which no strip is passing through the mill, and the instrument makes use of such intervals to carry out automatic standardisation. As the tail end of a strip passes through the mill, the measuring head is retracted by a pneumatic cylinder and the instrument checks itself against a standard sample which is automatically inserted into the measuring gap. If the equipment is out of adjustment, a servo system automatically applies a correction, thereby ensuring that the instrument is at all times operating correctly.

On the Tayler mill installation, the measuring head is situated between the nip and the reeler and feeds the main electronic console, which can be seen mounted on a gallery behind the mill in one of the accompanying illustrations. The minimum stable automatic control tolerance is ±0·00015in and the normal working tolerance in this particular installation is ±0·0003in.

As already mentioned, the radioactive source in the holder of the measuring unit is Strontium 90, the beta radiation from which impinges on a metal target causing a secondary electromagnetic radiation (X-rays) known as Bremsstrahlung to be directed at the detector. A shutter built into this unit has three apertures, one aperture being fitted with a standard sample of 0·030in material and another with a thick piece of lead: the third is left open. A solenoid operates the shutter to locate any one of the three apertures between the source and detectors. When automatic standardisation comes into operation, either the blank or the steel aperture is moved into position, depending on the setting of a range switch, i.e. when a low thickness range is being used (0·005in to 0·020in), standardisation takes place with zero thickness in the gap, and with a high thickness range (0·020in to 0·080in) the 0·030in standard sample is used. The lead aperture is moved into position by a manual standardise switch and is used for the adjustment of infinity setting.

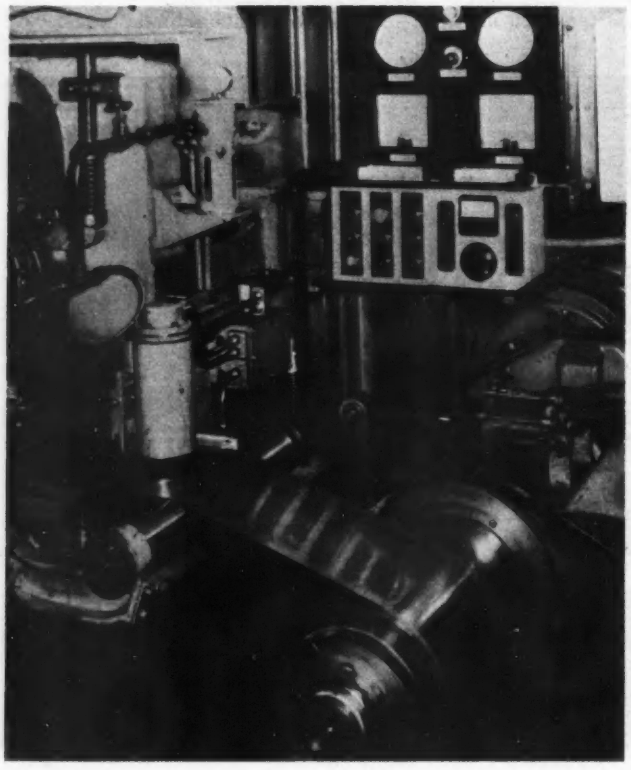
The detector consists of a sodium iodide crystal which is mounted adjacent to a photomultiplier, and when radiation strikes this



Outgoing side of mill with the operator about to switch in the automatic control system as mill speed is increased at the beginning of a reel

crystal, it scintillates to a degree proportional to the radiation intensity. The visible light thus produced is observed by the photomultiplier which generates a current proportional to light intensity, which in turn is proportional to radiation intensity and hence a measure of the thickness of the strip.

A rigid bracket carries the measuring head and the various components are housed in two cast steel units in which all the electronic equipment is suspended on anti-vibration mountings. The moving bracket is fixed to a massive steel base plate and is moved in and out of the measuring position by a pneumatic cylinder which is actuated either automatically or manually via a solenoid valve. A microswitch fitted to the base plate is operated when the measuring head is fully withdrawn and causes the automatic standardising procedure to commence. The measuring head can be clearly seen in its operative position in one of our illustrations.



Measuring head in operative position over strip being coiled with mill accelerated to maximum rolling speed. The indicator light panel can be seen in the background

The output from the photomultiplier is first backed off against the output from a potentiometric network which is arranged to produce a potential representative of the thickness at which the metal should be rolled. This potential is controlled by the set thickness potentiometer which is calibrated directly in units of thickness. If the actual thickness of strip at a given moment equals the set thickness, a balance is obtained and the input to the amplifier is zero. If, however, the actual thickness deviates from the set thickness, out-of-balance conditions maintain and a signal is fed into the amplifier. The input to the amplifier then is proportional not to thickness but to deviation. The highly stable low-gain d.c. amplifier used has a very high percentage of negative feed-back. The amplifier output moves positively as material thickness increases during rolling, negatively as thickness decreases, and is zero when no deviation occurs.

For the visual indicating equipment, a moving coil meter measures the output from the amplifier and indicates deviations from set thickness as they occur, and a strip chart recorder connected to amplifier output produces a permanent record of thickness deviations. Three sets of three lamps are mounted in one unit to indicate the mill conditions to the operator. In one set one lamp lights when automatic standardising procedure is in operation, when readings should be ignored. Another shows when the instrument has standardised itself and awaits the head to be restored to the measuring position, and a third shows when instrument is correctly set and is reading. In a group of shutter position lights, one lamp is illuminated for each position of the shutter. The third group of lights shows when the screwdown motors are stationary, moving up and moving down.

There are two variable qualities in metal rolling, thickness and flatness, and it will be appreciated that both are interrelated, and can each be affected by two variable controls, screwdown and tension. Without instrumental control a great deal of skill is required in order to achieve by trial and error a combination of screwdown and tension which provides acceptable thickness and flatness. This particular system of automatic gauge control is linked with the screwdown adjustment, and the operator is therefore concerned with only one variable control, tension, and one variable effect—flatness. In practice, it is usual to set the screwdown to some predetermined position which may be expected to produce strip within tolerance as regards thickness and flatness so long as the ingoing strip is of average condition.

Arrangements can be made to ensure that the control system is automatically inoperative when mill speed drops below a certain level, such as when running up at the beginning of a strip or running down at the end of a strip. Were this precaution not taken, the system would be likely to hunt continuously at low speeds. In the extreme case, if the mill stopped with an over-tolerance strip in the measuring gap, increasing pressure would automatically be applied to the rolls, and considerable damage might occur.

When the automatic control is switched on either manually or automatically at the beginning of a reel, the output from the amplifier is fed to a discriminator unit. Whilst strip thickness remains within the dead zone (in this case $\pm 0{\cdot}0003$in) the discriminator takes no action. When thickness enters the inner control zone, 0·25 second pulses at intervals of about two seconds are fed to relays which in turn cause the relevant screwdown motors to operate for periods of 0·25 second until either the thickness return to within the dead zone limits or moves into the outer control zone. If the thickness returns within tolerance, the discriminator of course returns to its normal condition. If the deviation exceeds $+0{\cdot}0005$in, the discriminator causes the relays and thus the screwdown motors to operate continuously until thickness is restored to within the inner control zone. The limits of the zones can be adjusted in order to meet the requirements of any particular specification. A microswitch can be fitted on the ingoing side of the mill to be operated by the trailing edge of a strip and stop the control system, and cause the head to withdraw for automatic standardisation to commence.

Automatic standardisation of the equipment is normally commenced when the microswitch on the measuring head is actuated by the withdrawal of the head bracket from the measuring position. This causes the requisite standard sample in the source holder to be switched into position and the output from the amplifier is fed into the discriminator. If the instrument is correctly set, the amplifier output is zero and the discriminator takes no action. If, however, there exists an out-of-standard condition, an out-of-balance output from the amplifier feeds into the discriminator which operates one of two relays, causing the servomotor to rotate. This motor changes the setting of a potentiometer which is connected directly to the photomultiplier and the motor continues to rotate until the photomultiplier output causes the input to the amplifier to reach zero, thus restoring the instrument to its correct condition. The discriminator in this standardising unit is identical to that in the automatic control system, and it has two distinct sets of operating conditions—for a small error, it pulses the servo-motor and for a large error, it causes the motor to operate continuously.

Boiler Availability Committee

THE Boiler Availability Committee* recently issued its ninth bulletin (MC/286), *Methods of Cleaning Modern Boiler Plant*. This is a revision of its first bulletin, extended to include external cleaning of pulverised-fuel-fired as well as stoker-fired boilers. Copies are obtainable from manufacturers of water-tube boilers. Whilst most of the methods described are probably applicable to oil-fired plant also, there is no widespread experience in Great Britain with large boilers fired with residual oil fuel, and the committee therefore recommends caution until further experience has been obtained. In 1945 the amount of coal burned in British power stations in pulverised form was relatively insignificant, yet in the twelve months ended March, 1957, about 25,500,000 tons were burned in pulverised form, representing 57 per cent of the total solid-fuel consumption in power stations, and this percentage is rapidly increasing.

The investigations made by the committee are now almost entirely long-term. In recent years close liaison has been instituted with the A.S.M.E. Research Committee on Corrosion and Deposits from Combustion Gases, particularly with regard to large oil-fired boilers. More recently, Electricité de France has co-operated in similar investigations. Teams of research workers of the B.A.C. have made visits to French power stations, notably at Nantes Chevire on 500 klb per hour oil fired boilers.

In addition to laboratory-scale investigations by the research bodies, the Research Department of the Central Electricity Authority and many of the boilermakers, large-scale investigations are also being conducted in many of the power stations operated by the C.E.A.

* This committee consists of representatives of the Central Electricity Authority, the South of Scotland Electricity Board, the Water Tube Boilermakers' Association, the British Coal Utilisation Research Association, the Fuel Research Station of the Department of Scientific and Industrial Research, and other manufacturers of boiler plant equipment. It was convened during World War II, when it applied itself to short-term means of alleviating availability troubles, particularly with regard to stoker-fired plant.

Water Treatment at Pitsford Works

By J. W. MILNE, A.M.I.C.E.*

Here we print abstracts from a paper entitled "The Pitsford Treatment Works of the Mid-Northamptonshire Water Board" presented at the winter meeting of the Institution of Water Engineers on December 6. The full paper gives a detailed description of all the principal elements at the Pitsford plant.

SOME of the processes used in the Pitsford treatment plant, for instance the bulk handling and automatic mixing of chemicals, and the centrifuging of sludge, are novel in the water supply industry, although they are employed elsewhere. Others, such as the automatic operation of the filter plant, are interesting, but not new. Again, very extensive use has been made of electrical instruments and push-button control throughout the works. It is felt that the combination of all these features in one plant merits description.

Pitsford reservoir is on a tributary of the River Nene, about 5 miles north of Northampton. The catchment area is 11,800 acres, the average annual rainfall 25in and the estimated net reliable yield is 4in. The yield from the reservoir catchment will be supplemented by pumping from another branch of the River Nene at Duston Mill about 7 miles away, and it is estimated that 7·75 m.g.d. will be available from the reservoir for supply.

The specification for the treatment plant, in addition to the usual chemical and bacteriological requirements, called for equipment to produce 10 m.g.d. of water having a total hardness not exceeding 120 p.p.m. Samples, taken over a number of years from the Pitsford stream and from the River Nene, indicated that the total hardness of the raw waters before impounding varied between 190 and 350 p.p.m. with an average value of 260 p.p.m.

Basically the treatment plant comprises eight square hopper-bottomed upward-flow sludge blanket tanks, with eight rapid gravity filters arranged alongside. Around this reaction tank-filter group the other buildings were planned to form a compact mass, with tank walls performing the dual purpose of load bearing and water retaining wherever possible.

The chemical block is a two-storey building with a central tower structure. The upper floor contains the 1200-gallon alumina-dissolving tanks, 1200-gallon lime-mixing tanks, and 5000-gallon soda ash dissolving tanks, all in duplicate. The lower floor houses the eight reinforced concrete combined mixing tanks, each of 3500 gallons capacity, together with the chemical injection pumps, flash saturators, and the pneumatic handling equipment. The central tower is formed by a group of four storage bunkers each of about 80 tons capacity, three of the bunkers holding hydrated lime and the fourth soda ash. A shaft runs vertically through the middle of the bunker group giving access to the machinery room at the top.

Reaction Tanks

A cross-section through the main treatment plant block is shown. On either side of the raw water inlet channel there are four reaction tanks, each of which is supplied through a hand-operated disc valve in the floor of the channel. Raw water enters at the bottom of the tank from a vertical pipe which has a Venturi throat at which preformed sludge and water may be drawn in to mix with the raw water before meeting the softening chemicals, which are injected near the bottom of the tank. This hydraulic recirculation process provides agitation for the completion of the softening process, which would otherwise have to be produced by paddles, or similar mechanical means. Cone valves, at the throat and the exit from the recovery cone, enable the correct velocities at the throat and at discharge to be maintained for different outputs. Water rises up through the sludge blanket zone, and is collected in a series of asbestos decanting troughs which deliver the softened water to a conduit immediately under the raw water channel. The capacity of each tank is 79,000 gallons and the upward velocity in the top 30ft 7in square section is about 1¾in per minute at maximum output.

At a level of 325·25ft O.D. two small hoppers are provided on the side of each tank from which sludge is bled off in a regular time cycle. The hoppers in each tank are operated alternately, the sludge being discharged, through solenoid-controlled hydraulic valves, under hydrostatic head to a pair of channels in a gallery beneath the softened water channel. The main tanks can be desludged manually under hydrostatic head. At the end of each sludge channel a Venturi flume has been formed in the concrete, and instruments indicate and record the quantity of sludge discharged. This measurement is not essential to the operation of the plant, but does assist in forming a complete picture of the use of water throughout the works.

The sludge is discharged to a hopper-bottomed tank at the end of the gallery in which the first stage in the dewatering of the sludge takes place. The process is one of sedimentation, the supernatant water being drawn off over a central circular weir, and pumped back to the raw water channel. The sludge from the hopper bottom is pumped to the sludge disposal plant described later.

The maximum quantity of sludge of 5 per cent concentration to be handled by the concentrator is 80 g.p.m. continuously from the sludge bleeds plus 300 g.p.m. for 3 to 5 minutes when a reaction tank hopper is desludged. Sludge discharged from the concentrator is of about 10 per cent concentration, and hence the maximum quantity of sludge to be dealt with by the disposal works is about 2500 g.p.h.

Filters

There are eight filters each of 435 square feet effective area, and designed to operate at a maximum rate of 120 gallons per square foot per hour through graded media 3ft 6in deep. They are arranged in one row and are fed from the softened water channel through 12in diameter disc valves.

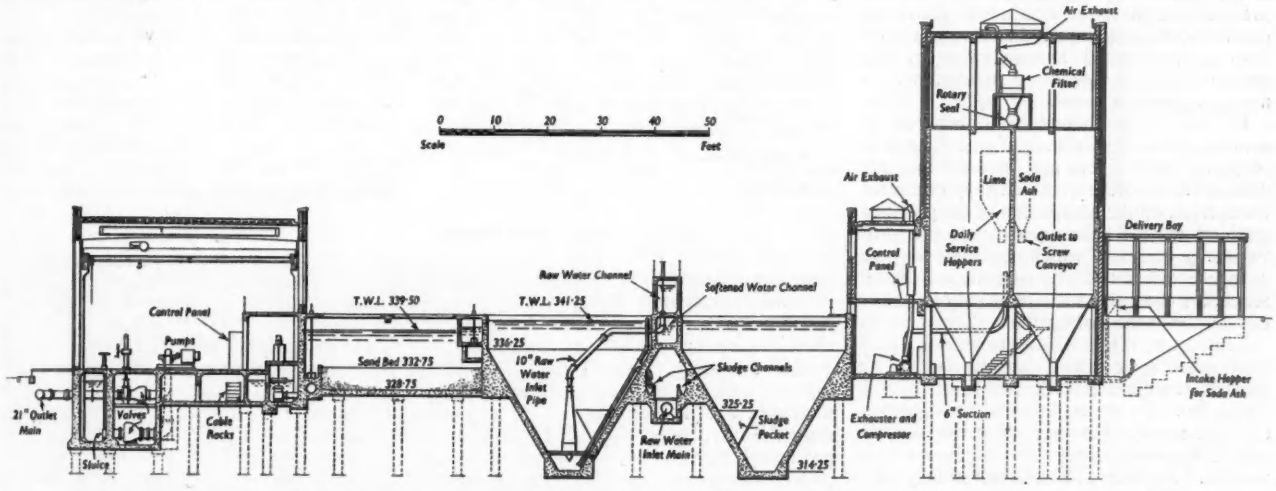
Operating in conjunction with each filter module there is an automatic controller which carries out the following functions :—

(1) Shuts down the filter and maintains the filter bed waterlogged should the raw water supply to the plant cease.

(2) Shuts down the filter when it has drained to a level at which washing can be carried out.

(3) Brings the filter slowly into operation after washing in any desired period.

The main valves for controlling the inlet, upwash, washout, and air are fitted with slave cylinders, and operated hydraulically by oil pressure supplied by motor-driven pumps. The pumps are in duplicate, one working and one standby, and there is a hand-operated transmitter for emergency use in the event of failure of the electricity supply. Hydraulic feed lines in pairs run round the eight filters, each pair of lines serving either as pressure or exhaust to one set of filter valves, namely inlet, upwash, washout, and air. Filter rate of flow and loss of head indicators together



Cross section through main block of treatment plant, showing chemical block, reaction tanks, rapid gravity filters and filtered water pump house

* Deputy Engineer and Manager, Mid-Northamptonshire Water Board.

with indicators showing the position of the inlet, washout, upwash, and air valves for each filter, are mounted on the main panel. These features are now common on many filter installations.

With the object of reducing the labour required to operate the plant, fully automatic filter washing was installed. This feature, although by no means as common as those previously mentioned, has been incorporated successfully in a number of filter installations. The complete operations required for successive filter washing are controlled by an automatic sequencer ; an outline only of the method of working will be given here.

The sequencer consists of a control desk situated in the filtered-water pump house in front of the main panel, and contains the automatic relays, timers, and switches for controlling the filter-washing process. The washing cycle is initiated by the loss-of-head gauge through a differential-pressure switch which transmits a signal to the sequencer when the permitted head loss in any filter has been reached. On that particular filter the sequencer operates a solenoid-controlled selector valve which opens a multi-port hydraulic valve bringing the main filter valves into direct connection with the oil pressure lines. The washing cycle is then carried to completion, the various stages of inlet valve closing, air valve opening, &c., being dictated by master valves in the oil pressure lines near the transmitter under the control of the sequencer. Pressure in the oil lines is maintained automatically by the pumps which operate in conjunction with a nitrogen pressure vessel.

If other filters indicate that they require washing while the washing of one filter is in progress, those filters are lined up and are washed in the order in which they presented themselves, on the completion of the previous washing cycle. Selector switches are provided, by means of which any filter may be changed from automatic sequencer to hand sequencer control, or the filter may be taken out of the circuit altogether. Signal lights indicate those filters which are working normally and those which are waiting to be washed, and dials show the first three filters in the queue. On the main panel an eight-pen recorder shows when each filter was washed and the length of time occupied in the washing process. All filter solenoid valves may also be operated manually.

Chemical Mixing and Feeding

The mixing of lime and the dissolving of soda ash and alumina are carried out in tanks in the upper floor, the individual chemicals being fed by gravity to the combined mixing tanks on the lower floor. The layout of the tanks and the interconnecting pipework is shown diagrammatically.

So far the handling of chemicals has been dealt with [in the original paper] up to the stage of their being ready for dissolving or mixing in individual tanks, and the following operations now require consideration :—

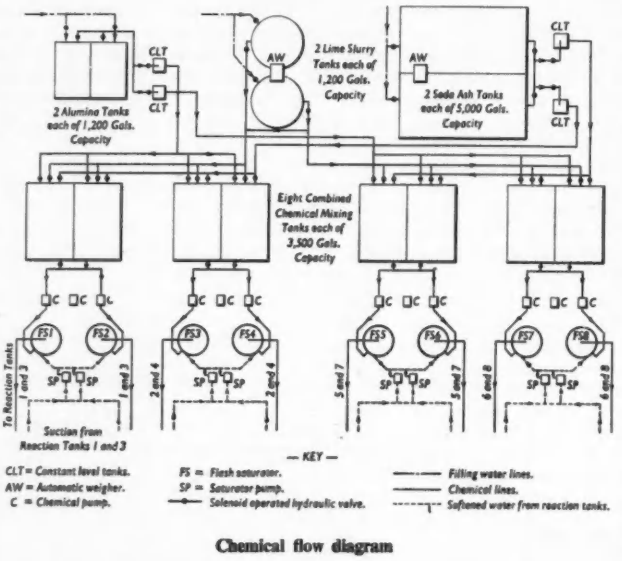
(*a*) Adding water to the dissolving and mixing tanks.

(*b*) Operating the agitators in the alumina and lime tanks and the circulating pump for the soda ash tanks.

(*c*) Discharging each chemical to the combined mixing tanks and the topping up of these tanks with water in a predetermined cycle.

(*d*) Discharging the combined mixing tanks.

For dissolving alumina and soda ash, and for mixing lime, there is one working tank and one standby tank. Four combined mixing tanks are in use while others are awaiting or receiving a fresh charge. Alumina and soda ash solutions are fed to the combined mixing tanks, through small constant-level tanks which control the rate of flow. The maximum quantities of alumina and soda ash solutions to be fed to a selected combined mixing tank continuously are 300 and 1250 gallons respectively. No control of the quantity of lime slurry discharged is required as the selected combined mixer receives the full contents of the mixing tank, namely, 1200 gallons containing the preset quantity of lime. The topping up of the combined mixing tanks with water is done via the lime mixing tanks, in order to flush out the delivery lines after a lime tank has been emptied. The combined mixing tanks and reaction



Chemical flow diagram

tanks are arranged in two groups of four each the interconnections being such that it is necessary to charge one combined mixing tank from each group once every six hours.

The foregoing operations (*a*) to (*d*), together with the batch weighing of lime and soda ash, and the switching of the weighers from the working to the standby tanks, are controlled automatically from an electrical panel situated in the upper floor of the chemical block. Part of this control panel consists of a mimic diagram showing the operations in progress and also housing the tank selector switches and contents gauges for the combined mixing tanks.

All valves for controlling chemical and water flows are hydraulically operated, a solenoid valve admitting motive water pressure in every case. The solenoid valves are those controlled from the panel, and operate in conjunction with time switches and float switches. The time switches determine the quantity of alumina and soda ash solutions discharged to the combined mixers, the water to be added to the lime mixing tanks and the combined mixing tanks, and the operating time of the alumina, lime and soda ash agitators. The float switches cut off the water supplies to the alumina and soda ash tanks. The chemicals from the combined mixing tanks are injected into flash saturators by variable-stroke metering pumps. There are three pumps to each pair of combined mixing tanks, two pumps working and one acting as standby. When a combined mixing tank is put out of use by switching at the control panel, the standby tank is brought into use automatically so that there is no interruption in the supply to the chemical pumps. The purpose of the flash saturators is to bring the lime into partial solution ; this is accomplished by mixing the chemicals in the saturator chamber for a period of about four minutes with softened water drawn from each reaction tank by means of a centrifugal pump, which also discharges the solution from the chamber to the reaction tanks.

Washwater and Sludge Disposal

In the lime soda softening process, the disposal of sludge in large quantities is a problem. Consideration was given to (*a*) the drying of the sludge in beds or lagoons and its removal therefrom by scraper or dragline and dumper, and, alternatively (*b*) the dewatering of the sludge sufficiently by filtering or centrifuging to enable it to be loaded directly into dumper or lorry for disposal. The arrangement (*b*) was adopted, and it is believed to be new to waterworks practice in this country. Sludge from the concentrator and from the washwater settling tanks is pumped to the working centrifuge through a 3in diameter asbestos cement main provided with manholes for rodding at suitable intervals.

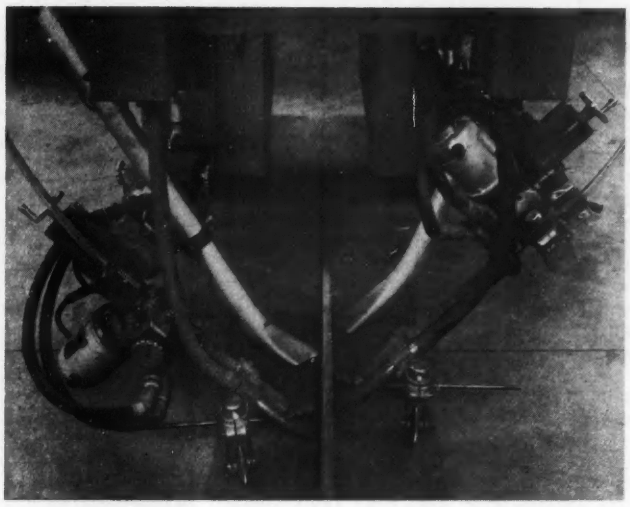
The centrifuges are each driven by a 30 h.p. d.c. motor with speed variation from 1000 to 2000 r.p.m., current being derived from the rectifier on load in the raw water pump house. The maximum quantity of sludge to be fed to a centrifuge is 2500 g.p.h. at 10 per cent concentration, and the moisture content of the sludge cake after centrifuging is of the order of 40 to 50 per cent by weight. The sludge cake is discharged from the centrifuge to a horizontal conveyor capable of storing 10 hours maximum output of sludge cake, or about 16 tons. Each conveyor has a 5 h.p. a.c. motor drive, and the speed may be varied through a gearbox from 0·076ft to 2ft per minute, the higher speeds being used when the conveyor is discharging to the lorry or dumper.

In the first instance the sludge is being dumped on low-lying ground adjacent to the works, from which the top soil has been removed for use in resoiling after filling. However, the building at the discharge end of the conveyor has been so arranged that the sludge may in the future be delivered to a calcining plant, but apart from reserving space for the buildings, no detailed thought will be given to this until the nature and quantity of the sludge are better known.

To guard against breakdown of the sludge plant, it was considered desirable to provide one emergency sludge bed adjacent to the washwater settling tanks. It is of reinforced concrete construction with drainage channels in the floor and also a floating arm in a well at one corner for drawing off the supernatant water which is discharged to the nearby pumping sump. Sludge may be diverted manually to the bed or automatically through the operation of solenoid valves in the event of failure occurring in (*a*) electricity supply to the centrifuge, (*b*) electricity supply to the conveyor, or (*c*) the shear pin of the centrifuge gear unit due to overloading.

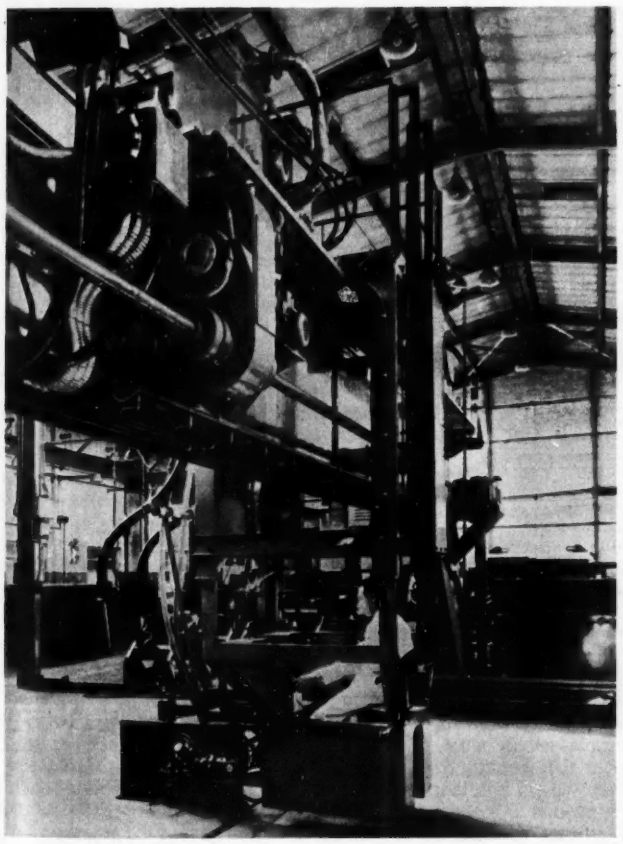
Welding Gantry for Shipyards

A machine which has been developed by Quasi-Arc Ltd., for welding stiffeners to bulkhead panels in shipyard fabricating shops, is operated by two men only. This equipment consists of a gantry with a carriage on which two welding heads are mounted. As the gantry is traversed over the stiffeners they are fillet welded on each side by the "Unionmelt" heads. As illustrated below, the machine operator sits at the controls in a cab immediately behind the welding heads, shown in detail on the right, as they travel along the work.



WELDING heads made by Quasi-Arc, Ltd., have been adapted during recent years for many kinds of special purpose equipment designed to ensure consistent quality and reduce the time and effort entailed in long run work on large and heavy weldments. An interesting example of this class of equipment, which was recently developed and built by the firm for use in the prefabricating shops of shipyards, is designed for welding stiffeners to bulkhead panels. It fillet welds each side of a stiffener simultaneously under the control of one operator. The machine consists essentially of a gantry which spans the working area and supports a carriage which can be traversed along its full length. A vertical slide on this carriage is fitted with two welding heads one of which registers on each side of the stiffener to be welded. As the gantry is traversed down the length of the bulkhead panel the heads simultaneously fillet weld it to the stiffener. At the end of each working traverse the gantry is returned at high speed to the head of the panel and the carriage is then moved along the beam to register the welding heads by the adjacent stiffener ready for the next cycle of operations.

The first of these equipments, which has been in operation at a large shipyard for some time now, can be seen in course of erection at the maker's works in the accompanying illustrations, and its general design is shown in the drawing on page 866. The gantry is a rigid structure of welded steel plate which spans a 36ft wide working area and is carried on rails at 45ft centres. It is traversed along the rails by a 6 h.p. d.c. variable speed motor, which is situated at the centre of the box beam and supplied with current by a Ward Leonard set mounted at one end of the beam. Electronic speed control equipment is provided to give a stepless range of welding traverse speeds from 6in to 60in per minute, and a high return speed of the gantry of about 50ft per minute to the head of the working area at the end of each welding pass. The drive is transmitted through reduction gearing, drive shafts and bevel gears to one traverse rail wheel on each column of the gantry. A friction brake on each traversing rail wheel is set slightly to preload the transmission and ensures a smooth positive drive at all times. Change-over from welding to high speed return traverse is effected through electromagnetic clutches, and for safety purposes can only be effected by an operator standing at a control station at the foot of either column facing the direction of travel. Welding traverse speeds are indicated on a tacho-generator dial situated on the main control panel.



Operator in the gantry cab which carries the two welding heads and control

The carriage is built up of welded structural steel members and it is supported from wheels running on tracks along the top of the gantry beam. It is traversed manually along the beam by the turning of a handwheel which turns a pinion meshing with a rack extending along the underside of the beam. The lower part of the carriage frame is slidably mounted in the main structure and on it there are carried an operator's cab and the two welding heads. This vertically adjustable sliding assembly is counter-balanced in the main carriage frame, and through a motor-driven winch it can be raised from rail level to a clearance height of 3ft 6in above the working area to clear the stiffeners during the return traverse of the gantry. With both heads in their welding position stiffeners spaced at a minimum distance of 24in can be welded to their panels, and the minimum height of a stiffener with a 3½in horizontal flange which can be handled is 5in.

On the top platform of the carriage there are mounted the welding rod reels, the melt supply hopper and the melt recovery equipment. The rod reels are each designed to take a 150 lb coil and they can be swivelled about a vertical axis so that the position of a reel can be adjusted to give the most convenient setting for wire take-off. An electric pulley block mounted on a swivelling jib is used for reel hoisting and loading purposes. The two melt feed hoppers supply the melt to the welding heads through an electrically controlled gate and flexible tubes. Unfused melt is recovered by vacuum pick-up nozzles behind the welding zone and returned via dust removal filters to the storage hoppers.

The welding heads are shown in their operative position in the illustration above.

They are generally of the firm's standard "Unionmelt" D.S. design, one being arranged for d.c. and the other for a.c. welding in order to reduce the interference between the two arcs. Each head is adjustably mounted on an inclined slide, and one is set a few inches in front of the other. The arms carrying the head slides are freely pivoted on the carriage structure, and actual support and positioning of the heads in respect to the work is by means of two guide wheels on each assembly. The vertically mounted support wheel of each head is tracked inwards, and it maintains a side distance wheel in constant contact against the stiffener. The pivotal mounting of the heads and the degree of positioning control exerted by the guide wheels enables the heads to follow any

deviation of up to 4in in the alignment of the stiffener on the panel.

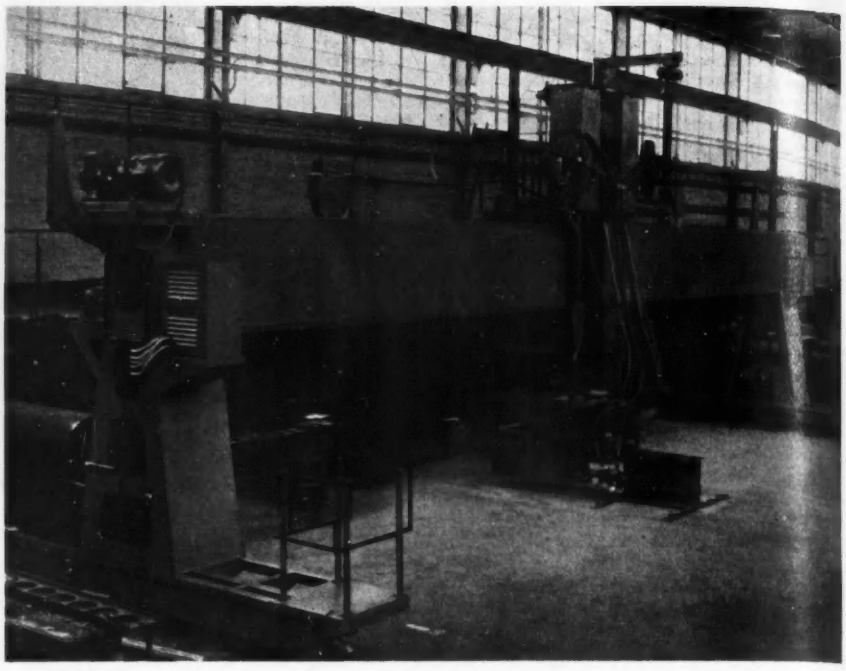
The power units supplying current to the welding heads are mounted one on each column of the gantry. A Quasi-Arc rectifier power unit on one column is designed for a continuous output rating af 600A. Its input transformer primary is wound for connection to 3-phase 50c/s mains with simple link changes at 360/380/400/420/and 440V. A magnetic amplifier provides current regulation from 120-600A and remote control at the welding head is effected by push buttons which operate a motorised regulator. An auxiliary transformer provides a 100/110V single-phase supply for the control circuits.

A 75kVA single-phase transformer power unit on the other column has a continuous output rating of 750A. Stepless variation of the welding current on load is provided by a remote controlled, motor-operated moving core reactor. The maximum load demand on this equipment is 600A. A 1kVA single-phase, air-cooled, transformer is provided to energise the control units, and a 32·5kVA capacitor for power factor improvement. Earth returns for both of the welding equipments are made by slippers attached to the bogies and sliding on the rails, and pads fitted in front of the slippers clean the rails to ensure effective contact.

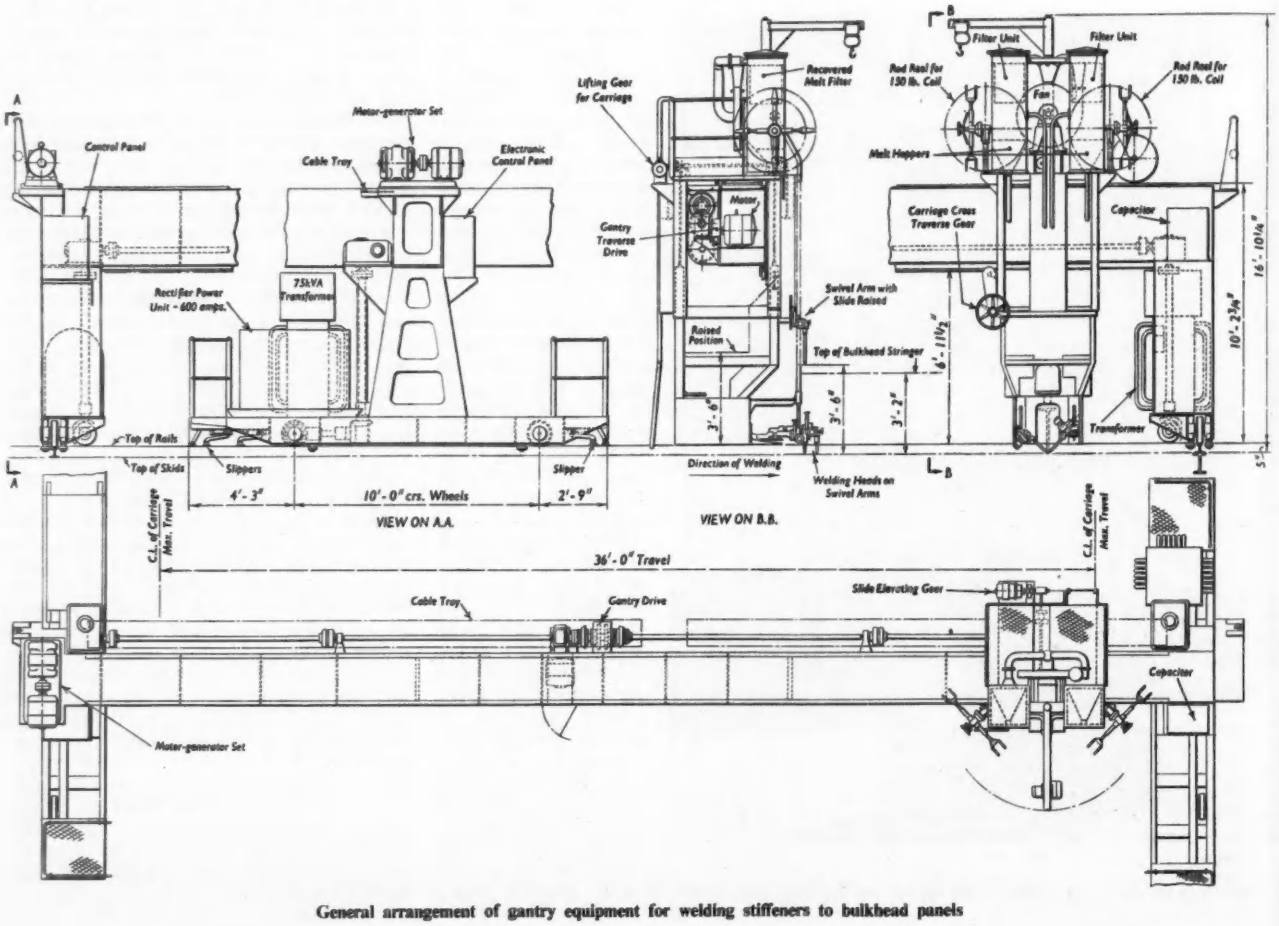
From his seat in the cab the operator has a clear view of the welding, and on each side there are panels with the controls for each head for melt feed and recovery, rod feed and retraction, welding current, current raising and lowering, voltage control. The main gantry controls are a selector switch for welding or high speed return traverse ; a forward stop or reverse welding speed traverse selector ; and a welding traverse speed control.

Although these gantry equipments have been initially developed for welding stiffeners to bulkhead panels they can be readily adapted for other classes of work involving long runs over large areas.

Furthermore, they can be fitted with different kinds of automatic heads, and it is of interest to note that the maker already has projects in hand for similar machines fitted with multi-power welding heads for butt welding of panels and sigma welding heads for the welding of aluminium structures. Other machines which are now being designed have combinations of welding heads which permit the same equipment to be used for either butt or fillet welding as occasion demands.



Welding gantry erected at maker's works. A short length of stiffener on a panel can be seen between the carriage-mounted welding heads



General arrangement of gantry equipment for welding stiffeners to bulkhead panels

Ram-Jets

By R. P. PROBERT*

The Royal Aeronautical Society yesterday heard the lecture from which we abstract below. Detailed studies of the control and stability of the ram-jet were included to show that its attractiveness was by no means superficial.

Intake Operating Problems

In many combustion chambers fuel is injected within the intake upstream of the combustion chamber and the intervening diffuser space constitutes a fuel mixing and carburation zone. Changes in mass flow distribution then lead to changes in mixture strength distribution in the combustion chamber, and of the two the latter is probably the more important direct effect. It is true, however, that the percentage variation in mixture strength is typically only one-half that of mass flow ; combustion equipment will usually, but not necessarily, continue to burn in such circumstances. Indeed, engine stability range may in some cases increase, but specific fuel consumption will increase. But primarily it is changing distribution, rather than bad distribution, which leads to operational difficulty.

Intake instability is a rather different issue. Should an engine inadvertently enter this region of intake operation the flame may go out, or the engine may continue to oscillate indefinitely or, it may recover with change of operating conditions. There is no universal rule. But most intakes have some range of stable flow reduction at lower speeds and, accepting a loss of latent thrust somewhere over the flight speed band, operations can be planned to avoid the unstable region. However, a little interesting work has been done on an automatic stabiliser or "shock catcher," which can prevent the worst effects of intake instability. It is shown in Fig. 1. A plain cylindrical shroud of diameter greater than the inlet is mounted ahead of the inlet and an axial gap left between the two. This shroud adds only slight drag due to friction, and during normal operation of the intake it has no effect on its behaviour. Should the design shock system become unstable then, during oscillation, it enters the shroud and immediately "pops" forward to emerge as a normal shock ahead of the shroud. The system now acts stably as a pitot intake at lower recovery, and excess air the engine cannot swallow at this lower recovery is leaked through the axial gap. Owing to the mass flow change the device can only be used over a range of Mach numbers where the associated change of mixture strength does not exceed the combustion chamber mixture limits. To return the system to normal duty fuel flow must next be reduced, while the total out-flow area (bleed area plus intake throat) is closely explained by the minimum contraction rules for internal compression intakes. After restarting, the mixture strength will be weaker than normal and the intake running supercritically, so the last action is to increase the fuel flow again towards the limit defined by intake stability.

All supersonic flow systems require variable geometry for the best results over a range of Mach numbers, and here one would like to push the shroud forward and increase the spill flow area with Mach number. Obviously this device and its associated fuel control technique do not mate with the requirement for simplicity in a missile engine. Ideas that really work are rare and other circumstances may find employment for this one.

* National Gas Turbine Establishment.

Combustion

From the beginning, work at the National Gas Turbine Establishment has tried to establish a type of combustion system adaptable, with variations, to all needs, and the constant theme has been the use and improvement of pilot systems. The simple idea here is to divert a fraction of the air into a sheltered region, physically separated

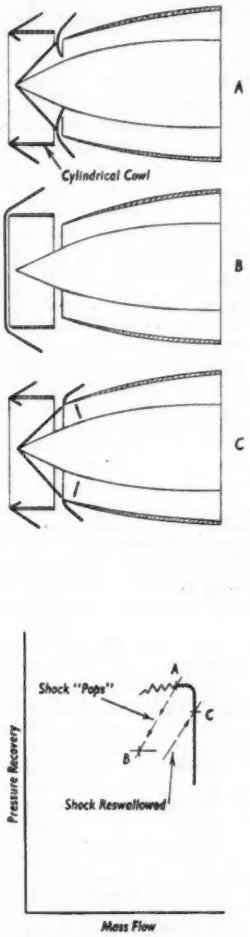


Fig. 1—Prevention of flame out due to "buzz" by intake cowl

from the main flow, in which lower mean axial velocities are maintained and where fuel concentration and gas mixing patterns can be reasonably well controlled within the pressure drop available. Having created a stable flame, efficient under all operating conditions, it is used to ignite the remaining fuel and air by-passing the pilot. This constitutes a two-stage system where thrust is altered by cutting off fuel supply to part of the by-pass air only, still leaving the cruise fuel to burn at optimum conditions throughout the thrust range. This technique is now very widely used and seems obvious, but its virtues were not always universally seen or admitted.

It was soon realised that the high diffuser approach velocities were enough for good air blast atomisation, and that diffuser length could be used for the dispersion of fuel injected upstream and, also, for evaporation at the ram temperatures met in supersonic flight. With the fuel already distributed and treated it was possible to put greater flows through the pilot.

Systems of this general pattern have been studied in detail over a wide range of mixture, operating pressure and temperature, and variation of design. As a whole results are consistent. For example, the farther upstream the injection station, the fewer jets are required, the more ignitable is the mixture and the more difficult it is to protect the pilot from mixture changes due to turn down of selected fuel jets for cruise. Low fuel pressures only are required, provided a clean air blast effect is secured by making sure that the fuel is thrown clear and does not dribble. Thereafter, the lower the pressure the less variation there is in distribution with change in speed and altitude. These systems can all be made to work quite well, although increased care and refinement are needed for operation at low pressure and temperature.

Ground and Flight Development Problems

For ground development a ram-jet must have independent air supply and exhaust services. This bitter necessity was always an argument against the ram-jet, but ironically the bulk services it really required awaited the day when the turbo-jet, finding its own progress hindered by the same restrictions, commanded and shared even larger resources. Indeed, to retain his title the early ram-jet exponent had to be a real improviser. At N.G.T.E. we developed specialised designs of air ejector for altitude testing, we boosted them by heating the driving air to 2000 deg. K. and flashing off steam to increase the driving mass and power, and temporarily, we had to modify "Nene" engines to supply air by bleeding. Even so, with one thing and another, our first 16in engine was actually flown when only one half section of it had been ground tested.

Ram-jet flight testing confronts the research engineer with an agonising dilemma. He is not producing an article for regular use under defined conditions ; he must try new things, test their capabilities and his understanding, and let practice sharply teach him right and wrong. In ram-jet research trials human lives are not at stake, although human reputations possibly are, and every engine in ballistic trials is destined for loss on return to sea level ; one is therefore uniquely free in every trial to reach the limits of failure in performance or mechanical operation. Each flight should carry graduated risks of several different kinds to explore extremities in many aspects of design and operation. The art is to arrange that any total failure will be due to the last risk taken. But logic never rules ; conscience must sometimes yield to the prejudices and necessities of life. One must put up an occasional dull success to buy time for a batch of intriguing failures.

The test vehicle used by N.G.T.E. for flight trials has undergone continuous development at the hands of the establishment and D. Napier and Son, Ltd., by whom it is manufactured. Its objects were to try out combustion, fuel control, cooling and intake techniques in flight, to confirm, deny or extend ground results and, above all, to throw up the problems of application

and keep research and development on a realistic basis. The flight envelope chosen was speeds up to $M=2\cdot5$ and heights up to 60,000ft to 65,000ft.†

It began as a dart of 600 lb weight launched by four forward wrap-round boost rockets, weighing 800 lb, to a launch speed of $M=1\cdot55$;

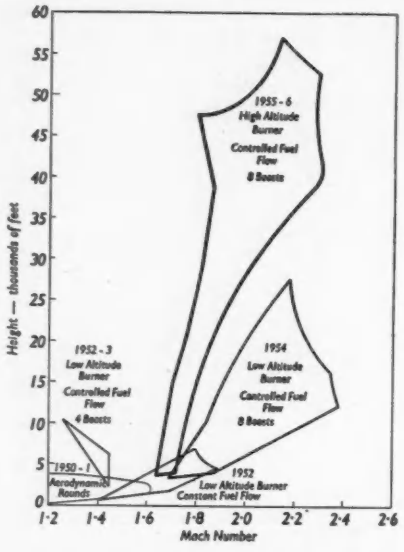


Fig. 2—Flight envelope of test vehicle trials

a light, cheap system. This arrangement was made to work, but uneven thrust decline of the separate boost motors led to excessive pitching of the dart at boost separation, with attendant protest by range staff and loss to us of control of the required flight trajectory. It now flies with eight rear wrap-round boosts of 1800 lb weight in a lengthened version of 950 lb weight to the higher launching speed of about $M=1\cdot75$. The vehicle is about 20ft long and 18in overall diameter. The front is a steel shell comprising intake and ducting spanned by a flat centre body housing fuel, pumping and control gear, instrumentation and radio transmission apparatus. The rear is a steel monocoque carrying stabilising fins, boost combustion unit, liner and nozzle. A total of about thirty launches has covered many aspects of the design and operation of engine components and of the vehicle and its equipment as a flying tool.

In fact, roughly one major change per flight was made to the engine, the vehicle, the equipment or the flight envelope, and each one was equivalent to roughly ten permuted flights on the shot-gun technique. This can only be done by treating each trial as an elaborate, specialised affair based upon the sum total of previous data and experience, to be followed by detailed study of the flight records and intensive ground checking of any observed flight peculiarities. One can then leapfrog economically over groups of issues together. It calls for flexibility and unnatural forgiveness in drawing offices and shops, but these virtues our associates at Luton possess.

Regrettably, one trial was a perfect, unblemished success ; obviously we picked too easy a target and wasted a round. In eight trials we did a little better ; they too were evident successes, but we found a few useful private snags. Another ten were tolerable compromises and of the rest, five were really fine failures stimulating streams of inquiry, speculation and invention. Fig. 2 shows the record of speeds and heights covered so far.

† Illustrated on page 484, THE ENGINEER, September 30, 1955.

Electrical Generating Equipment for Aircraft

MANUFACTURE of aircraft electrical equipment by the English Electric Company, Ltd., commenced with actuators for its own "Canberra." The Aircraft Equipment Division is now able to produce all the components of aircraft electrical systems, and has supplied for the "Canberra" 28V generators running between 2800 and 10,000 r.p.m. For such applications as this the generators must be run hot and withstand the admission of cooling air at, say, −40 deg., while severe brush wear is anticipated due to the absence of moisture. A distinctive form of commutator construction that has been evolved is shown in Fig. 1. The creep strength of conventional commutator copper alloys was found to be inadequate, even at temperatures of 180 deg. to 200 deg. Cent., and the bars in this machine contain up to 0·9 per cent chromium. This material responds to heat treatment, has an ultimate strength of 32 tons at room temperature and 25 tons at 200 deg. Cent., and is available in stock up to ⅜in : the conductors are brazed on by a resistance heating method which affects the properties only locally. The segments are clamped around the hub, insulated by "Micanite," and a V-section groove turned in each end of the commutator. The assembly is then secured by V-rings entering the grooves, similarly insulated, and kept tight at all temperatures by a spring of Belleville washer configuration. The assembly is then sub-

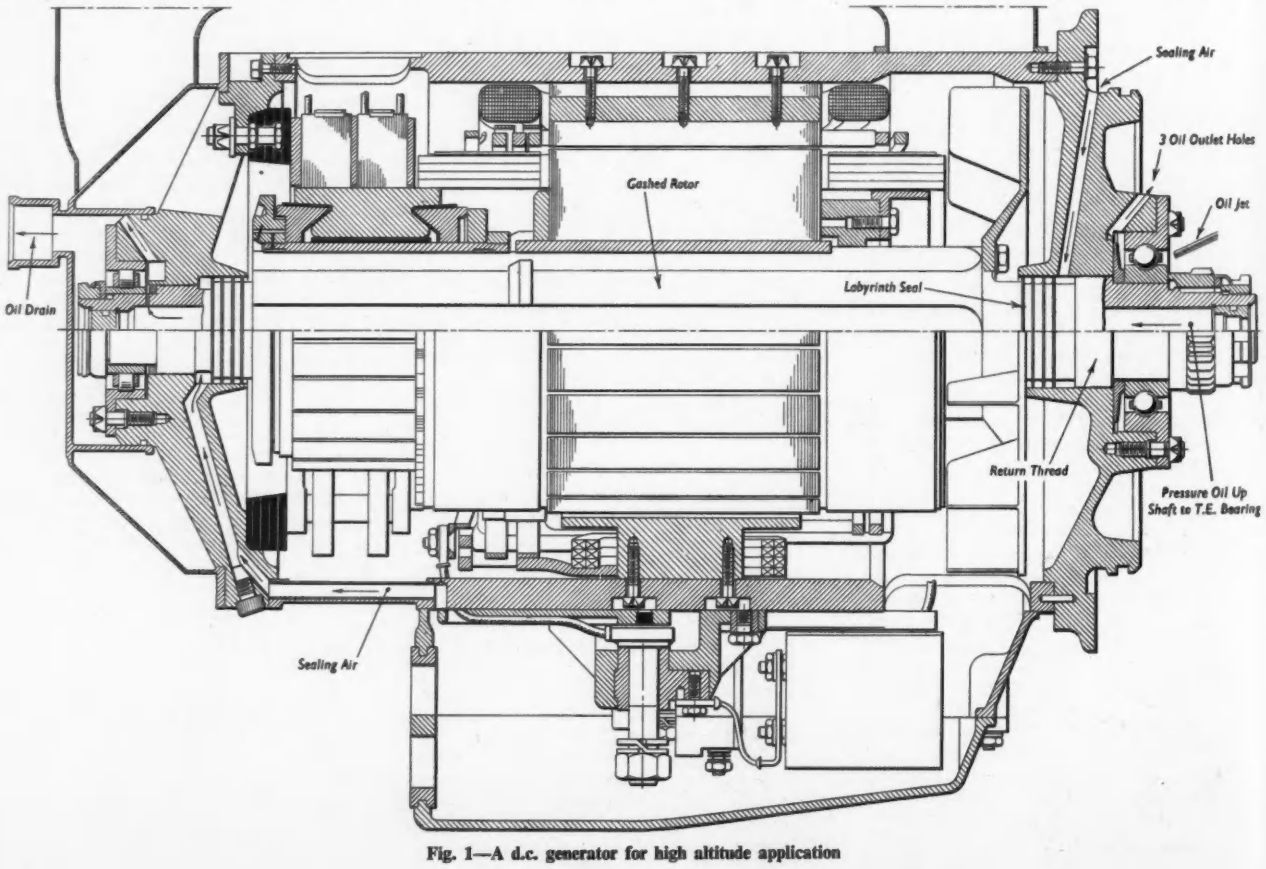


Fig. 1—A d.c. generator for high altitude application

jected to overspeeding and to thermal cycling up to 190 deg. Cent. Finally the running surface is machined : this method of construction is so stable that it is not necessary to run the commutator at operating speed (up to 10,000ft per minute) when finishing it. For these machines irregularities of the order of 0·0001in between adjacent segments are important, and to

Fig. 2—Brushes for high altitude use, incorporating molybdenum disulphide cores

detect movements of the bars at speed a capacitance pick-off of very short time constant is used : by triggering the display from one winding individual segments can be identified.

To shorten the bars, two rather than three brushes are used at each station. Alternate brushes have two and three cores of molybdenum disulphide : the illustrations here show that there is a definite difference in the wear of the profile where these inserts are, so that, molybdenum disulphide being a poor conductor, it appears that the current is

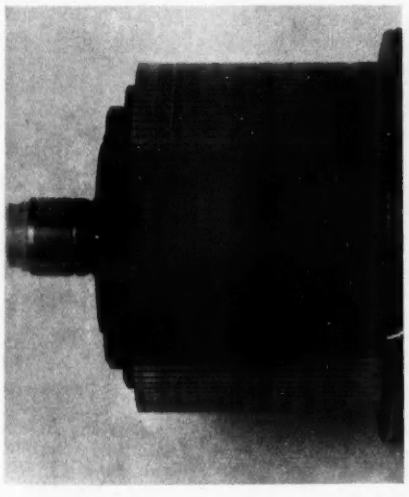


Fig. 3—A commutator which has been used with cored brushes

passed through an air gap. For these cored brushes wear is apparently independent of speed and altitude : a 300 hour run at a brush speed of 9500ft per minute and temperatures of 140 deg. to 180 deg. Cent. (measured by thermocouples in the brushes) in simulated altitude conditions showed a rate of wear of 0·0007in per hour for brushes that were not disturbed and 0·0011in per hour for brushes measured every 24 hours. Because of the abrasive nature of molybdenum carbide, it is anticipated that the limit to the loading of cored brushes will be set by the dissociation temperature of molybdenum disulphide. It is noteworthy that the angles between poles and between brushes are critical in such a generator : phasing is controlled within four minutes of arc, but brush temperatures vary as much as 25 deg. Cent. The shaft of the rotor is not circular in section, but longitudinal gashes are forged into it, lightening it with little sacrifice of bending stiffness and affording cooling air flow paths. The bearings may be lubricated with grease or, preferably, oil suspended in felt.

On some generators, particularly constant frequency machines, the bearings are cooled by oil taken from the engine or the Sundstrand hydraulic constant speed drive (see page 156, February 4, 1955). The lubricant will generally be an ester, and to resist its effect parts are protected with " Duromeg " A.S. 5305, a varnish which is very difficult to remove and so penetrative that masks of metal rather than tape are needed. The alternators are salient pole machines with the exciter commutator and sliprings adjacent : since the brushes are in series, the presence of oil is highly prejudicial, and sealing arrangements are critical. The illustration on page 868 shows a d.c. machine in which a return thread separates the bearing from a gland pressurised with air and a labyrinth completes the gland. This pattern has certain disadvantages ; the close clearances in the labyrinth render a bearing failure catastrophic even more quickly than might be the case, and the desired relationship between oil and air pressures may be difficult to obtain without a control valve in the air supply—a very difficult case would be the shutting down of a twin spool engine, when the air supply might collapse before rotation ceased. A preferred design uses, therefore, carbon glands, with the incidental advantage that precision machining is confined to small components rather than the rotor. It is preferred that the oil is not fed along the interior of the shaft, since the acceleration field is so intense that impracticable control orifices are required. Development work is also proceeding on the control systems for constant frequency supplies ; silicon transistors are expected to replace magnetic amplifiers in successively later stages of the control amplifier.

THE REASONING OF EUROPEANS*

By BERTRAND RUSSELL, O.M.

THERE are two very different ways of estimating any human achievement : you may estimate it by what you consider its intrinsic excellence; or you may estimate it by its causal efficacy in transforming human life and human institutions. I am not suggesting that one of these ways of estimating is preferable to the other. I am only concerned to point out that they give very different scales of importance. If Homer and Aeschylus had not existed, if Dante and Shakespeare had not written a line, if Bach and Beethoven had been silent, the daily life of most people in the present day would have been much what it is. But if Pythagoras and Galileo and James Watt had not existed, the daily life not only of Western Europeans and Americans but of Russian and Chinese peasants would be profoundly different from what it is. And these profound changes are still only beginning. They must affect the future even more than they have already affected the present.

For all this the Western world has the major share of responsibility ; and, because of this responsibility, it is incumbent upon Western man to supplement his scientific discoveries by the discovery of how to live with them. At present, scientific technique advances like an army of tanks that have lost their drivers, blindly, ruthlessly, without goal or purpose. This is largely because the men who are concerned with human values and with making life worthy to be lived are still in imagination in the old pre-industrial world, the world that has been made familiar and comfortable by the literature of Greece and the pre-industrial achievements of the poets and artists and composers whose work we rightly admire.

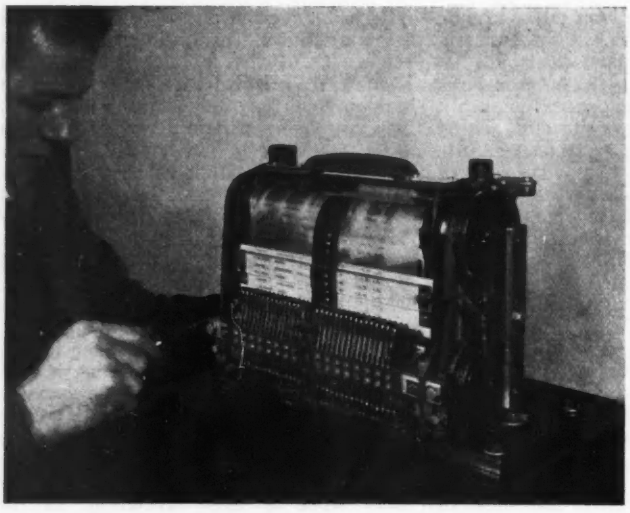
It is not the first time in history that a revolution in technique has caused a revolution in daily life. The same sort of thing happened, though much more gradually, with the adoption of agriculture as opposed to a nomadic existence. It is said, and no doubt with truth, that nomads have certain excellences which cannot be preserved in a stationary, agricultural life. Nevertheless, the spread of agriculture has been inevitable, although it was accompanied by ages of serfdom and oppression. Gradually, agriculture has been humanised, and we may hope that industrialism will be humanised more quickly.

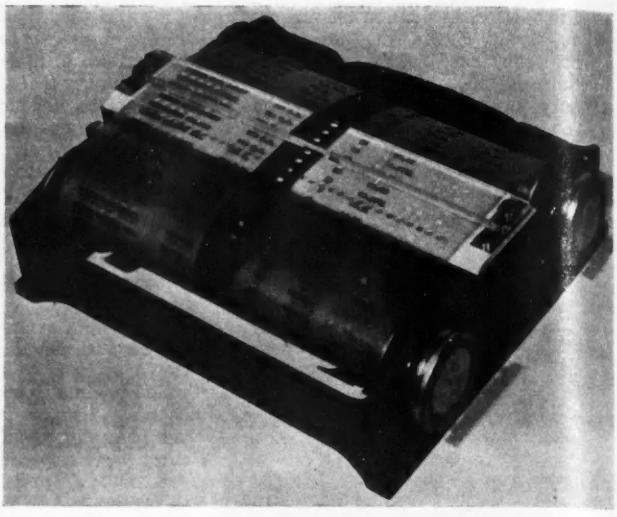
From a political and social point of view, the most important change resulting from industrialism is the greater interdependence of men and groups of men upon one another. Important industrial undertakings require the co-operation of large numbers of men, but what is more important, they require, if they are to be useful, the right kind of relations between the men concerned in the undertaking and the populations which it is to affect. Consider such projects as the St. Lawrence waterway, the irrigation of the Punjab, and the high dam at Aswan. All these raise international issues of the utmost delicacy. In a world of international *laissez-faire* the issues they raise can be decided, if at all, only after long, turbulent debates and contests of power. In such questions, as in the internal affairs of single states, there is much less room than there used to be for *laissez-faire* and much less room for individual enterprise, or even for the enterprise of a single nation.

It is growing increasingly difficult, in the world to which modern technique is giving rise, to preserve for the individual a sphere of initiative sufficient to stimulate his energies and give zest to his efforts. If the individual is not to shrivel and become desiccated through feeling himself merely an unimportant member of vast, impersonal organisations, something that seems both interesting and important will have to be found outside the main economic activities of communities. Many kinds of liberty, both personal and national, have become dangerous and need to be curbed. But liberty must have its place if men are not to lose stature. I am thinking not so much of liberty in the abstract as of the possibility of important achievement through individual effort. I hope that Europe, which has unwittingly created this problem, may also lead the way to its solution.

* From a B.B.C. broadcast on the General Overseas Service. Reprinted from *The Listener*.

SYNTHETIC RUBBER.—On Tuesday, December 3, Dr. W. J. Sparks, on behalf of the Esso Petroleum Company, Ltd., read a paper entitled " Development of Butyl; The Modern Synthetic Rubber." The paper discusses the development of Butyl, deals with the question of long molecules and compares the chemical structures of natural rubber and polyisobutylene and also various physical characteristics by means of graphs. Attention is paid to vulcanisation, the effect of fillers and to commercial development, particularly with regard to tyres. Figures are given related to tyre durability under load, and graphs record the cornering noise spectrum of Butyl tyres and data indicate the stopping distance, over a range of speed, required by a vehicle using Butyl tyres compared with the same vehicle using G.R.S. tyres.





(Left) A complete day's programme of trains on the central section of the Northern Line will be signalled in accordance with holes punched in a plastics roll which is passed through a programme machine. The punched holes correspond to the destination, route and timing of each train. (Right) One of the programme rolls in its carrier, removed from the programme machine

Programme Machine for Northern Line Signalling

WE learn from London Transport that completely automatic signalling of trains is soon to be introduced on the in-town sections of the Northern Line. Programme machines using instructions coded on punched tape have been developed by London Transport to carry out all signalling operations for running the full daily schedule of 900 trains to varying routes and destinations, replacing present manual signalling carried out from three signal cabins at Kennington, Camden Town and Euston. The first stage of the changeover will take place on January 15. There will be ten programme machines, each being fitted with 8in rollers. The rollers carry a moving plastics band (8in wide and about 8ft long) on which the complete Northern Line service in the north or south direction is translated into a system of punched holes. Each horizontal row of holes (as illustrated) represents one train with its timing, code number, destination and route via Charing Cross or City.

The plastics band is positioned for each train by a photo-electric system and a comb of thirty-two steel feelers " scans " one line of holes. The feelers that encounter holes in the plastics band cause a series of electrical contacts to close and actuate all the correct signalling, point and safety interlocking movements for the routing of a particular train in accordance with the time-table.

Where branches of the Northern Line fan out, the programme machine will send each train on its correct way. Where branches converge, the machine will signal trains through from each side in order of the time-table. But if a train from one branch is late the machine will appreciate the situation and send forward a train from the other branch. The fact that the other train is late will be stored in a memory device and this train will be despatched as soon as it arrives and the line is free. If trains are running late or not in accordance with the destination shown on the platform indicators, the machine will observe this condition and sound a warning buzzer to gain the attention of supervision staff. After the programme machines have signalled all the trains for a day, they will rewind themselves during the night in readiness for the next day. Different programme rolls will be provided for Saturday and Sunday services.

The programme machines will handle all Northern Line trains through the Kennington, Camden Town and Euston junctions. On the outer sections of the line signalling by normal methods will continue with signalmen controlling the trains, the programme machines taking over the trains in the central area. The working of the programme machine equipment will be supervised from a regulating point at Leicester Square. There a duplicate of each of the programme machines will be installed, along with an illuminated diagram of the line. Normally the small supervisory staff will not have to intervene in train operations, but push-buttons will be provided so that the line can be signalled manually in the event of delay or breakdown.

Programme machine signalling will begin at Kennington on January 15. The new machines at this point will be put behind a plate glass window so that passengers can watch them working. The changeover at Camden Town and Euston will take place over the next year.

The new equipment is being introduced to replace existing signalling equipment, much of which is over thirty years old, and it should promote operational economy and efficacy.

Two rubber-covered tubes laid across the road are connected to an electronic timer which measures accurately the time taken by the road vehicle to traverse the known distance between the two tubes

Electronic Equipment for Measuring Road Vehicle Speeds

AN electronic equipment for measuring the speed of a road vehicle has been developed by Venner Electronics, Ltd., Kingston By-pass, New Malden, Surrey, and is being tested by the Metropolitan Police on outer London roads.

This speed-measuring equipment was primarily developed for the Road Research Laboratories of the D.S.I.R. Basically it is a device for measuring small intervals of time with considerable accuracy. It consists of an electronic elapsed-time indicator connected to two rubber tubes which are long enough to span the road, each tube being connected to a pressure switch. The two tubes are laid across the road at right-angles to the traffic flow and spaced 70·4in apart. When the front wheels of the vehicle cross the first tube the pressure switch starts the timer and when the wheels cross the second tube the timer stops. The elapsed time is recorded by the meters, the pointer reading being persistent until the equipment is manually reset.

If this equipment is adopted it is expected that the rubber tubes may be laid semi-permanently at points known to be black spots and the equipment would be plugged in from time to time to discourage motorists from exceeding speed limits.

In this equipment the basic time element is a crystal oscillator operating at 10 kc/s. The output of this unit is passed to two binary dividers to give a 2·5 kc/s signal which, in turn, is fed to a gating circuit. The gate is opened by the passing of a vehicle over the first strip and closed by the vehicle passing over the second strip. The number of pulses passing through the gate whilst it is opened are counted by three decade counting stages with digital presentation on meters calibrated from 0–9. If, for example, the first meter indicates 3, the second 4 and the third 5, then 345 is the interval of time (in 0·4ms steps), during which the vehicle traversed the measured distance of 70·4in. The frequency and distance are chosen so that the speed of the vehicle is found by dividing 10,000 by the resultant indication. Thus, in the case given, the speed corresponds to 29 m.p.h. The accuracy is ±1 count for any figure recorded and thus, at 30 m.p.h.

(indication 333), the accuracy is to approximately ±1/3 per cent. At 100 m.p.h. (indication 100) the accuracy is within ±1 per cent. The equipment contains fifty-four transistors and is completely portable, the batteries being carried in the case, which measures 13in by 9in by 7in.

Modernised Machine Tool Works

A COMPREHENSIVE programme of extension and re-equipment which has been in progress during the past few years has just been completed at the Halifax works of Fredk. Town and Sons, Ltd. This firm, which was founded in 1903, was acquired by Thos. W. Ward, Ltd., in 1954, and the founder's grandson, Mr. Eric Town, was appointed director and general manager. It has long specialised in the manufacture of drilling machines, and now makes radials from 36in up to 8ft radius, and medium and heavy duty vertical drilling, boring and tapping machines. The modernisation scheme has increased the capacity of the machine shops by about a third, up to 24,000 square feet, and a general view of the main floor can be seen in the accompanying illustration. New machines installed under the re-equipment programme include two large Swift-Summerskill all-electric planing machines, a Lund "Precimax" 10in by 100in plain cylindrical grinder, a Pfauter spline hobbing machine and a number of smaller machines. The new heating system installed consists of radiation panels supplied with high pressure hot water from a central boiler plant.

The main shop comprises a long, low bay which is flanked on each side by high bays served along their full length by a 7½-ton capacity overhead crane. The main light machining area is concentrated along the low bay and the high bays are used mainly for assembly areas. The heavy production machines are grouped at the end of one of the bays, which is used for building and packing the larger models of radial drills and special machines such as girder mounted radial drills. A unit assembly section is situated at the end of the shop, adjoining a large stores for all parts made in the works and purchased outside. Under the production system followed, this stores batches together the necessary parts for each machine and issues them *en bloc* to the main assembly areas or unit assembly benches.

A foundry, with a capacity for castings up to 4 tons, immediately adjoins the stores end of the shop, and it delivers castings from the fettling section directly into the shop to a holding area near the planing machines. The large castings, after being machined in the heavy planing, turning, grinding and drilling sections, are passed on down the bay a relatively short distance to the assembly area. Lighter castings for the smaller machines are readily transferred across the end of the shop after machining to the head of the small machine assembly bay.

In general the work in the shop is organised on a batch production system and the straightforward design of Town radial drills lends these component parts to manufacture, using uncomplicated fixtures and jigs. Skilled fitting, as with all precision machine tools, is of particular importance, and this is kept to a minimum by the observance of close tolerances on all machined parts during manufacture. Special machines, or those normally required in very small numbers, are fairly readily accommodated in the normal production run by maintaining a degree of flexibility in all sections of the works, which is usually possible in a relatively small establishment dealing with one class of machine tool.

Re-equipped and modernised machine tool works

Detector for Flow Failure in Solid Materials

AN instrument has been produced by Bailey Meters and Controls, Ltd., Croydon, Surrey, to give a warning of any interruption in the flow of coal or other solid material, in a pipe or chute. The instrument is stated to cause virtually no obstruction to the flow; its operation depends on the detection and amplification of the vibration caused by the flow of the material. Transistors are used instead of valves in the amplifier circuits.

The device consists of a probe inserted into the pipe to make contact with the moving coal. The probe is acoustically isolated from the pipe itself. A vibration pick-up is fitted to that part of the probe extending outside the pipe. Any output from the pick-up is fed to a transistor amplifier which is tuned to accept a certain range of frequencies. The final stage of the circuit incorporates a relay to control the operation of the alarm and a time delay. Thus the instrument consists essentially of two basic components—a probe unit and an amplifier unit.

The probe unit is a length of 1¼in diameter mild steel bar, which projects into the coal pipe about ¼in. The bar is held in the centre of a mild steel sleeve by a layer of tough rubber. The sleeve is bolted into the fixing flange, which is itself bolted on to the pipe. Accordingly, the probe unit can be removed from the pipe for inspection and replaced without emptying the coal pipe or stopping the flow. The vibration pick-up is held at the end of the probe which is outside the pipe or chute. The probe unit is housed in a cylindrical casing $4^{1}/_{32}$in diameter by 4⅜in overall, and it is fitted to the coal pipe or chute by a bolted flange, 6in diameter. Normally this flange is suitable for an 18in pipe.

The amplifier is a four-stage circuit using junction transistors with a relay stage incorporating a time delay. The amplifier gain is temperature stabilised, being substantially constant up to at least 50 deg. Cent. Use is made of printed circuit technique, all components being mounted on the laminate.

To limit the attenuation caused by the self capacitance of the screened coaxial cable, which connects the probe unit and the amplifier, long cable runs should be avoided, 200ft being the maximum. The amplifier is contained in a wall-mounting case, measuring 4in by 7in by 11in (over the cable plug connection). An "on-off" switch is fitted on the side of the case.

We learn that the amplifier has given satisfactory operation at ambient temperatures up to 50 deg. Cent.; the maximum operating temperature of the probe is determined by the pick-up, whose temperature must not exceed 100 deg. Cent.

Power consumption (at 230V, 50 c/s) when the alarm is not operated is negligible (1W), so that power used is only that consumed by the alarm device itself. The relay in the amplifier unit is capable of switching about 20W at 230V and will, therefore, operate the normal 15W pigmy alarm light, or a low-power bell. For a klaxon or heavy-duty industrial bell an external relay would have to be fitted.

In some applications a longer time delay is required between the cessation of flow and the operation of the alarm than that provided by the built-in time delay in the amplifier unit. For example, if the feed to a pulverising mill is controlled by feeder table on-off or two-step-speed control, the coal flow down the pipe is then intermittent; usually the time for which the coal flow is stopped is in the region of fifteen to twenty seconds, but in some cases an "off" time of up to a minute is possible. By the addition of two more condensers in parallel with the two existing condensers in the amplifier, the time delay can be increased to a maximum of twenty-five seconds. For a greater time delay a supplementary time delay unit can be used.

Type of coal	Percentage by weight					
	Above ¼in	¼in to ⅛in	⅛in to ¼in	¼in to ⅛in	⅛in to ¼in	Below ¼in
Chislet untreated smalls	1	3	7	7	12	70
Betteshanger smalls	6	4	7	6	11	66
Snowdon untreated and dry-cleaned smalls	12	7	11	7	11	52
Rawdon 1in slack	13	11	12	7	11	46
Swadlincote 1¼in slack	18	9	12	7	11	43
Tilmanstone dry-cleaned smalls	11	6	8	6	8	61
Fife washed smalls and duff	12	8	11	10	12	47
Northumberland mixture	24	11	18	9	12	26

APPLICATION

It has been found that the signal produced by coal flowing past the probe varies with the size of the coal, the finer the coal the smaller the signal produced. Investigations into the sizing of coals used at C.E.A. power stations have shown that the coals normally used are large enough to give an adequate signal with the standard probe. For installations where the coal is very fine, a special probe extending 6in into the pipe is available; it may also be found necessary to alter the peak frequency of the tuned circuit in the amplifier, by changing the value of the condenser C.9.

The manufacturer gives examples in the table above, of analyses of some of the coals used at sites where prototype alarm units have operated satisfactorily with the standard probe.

We learn that only one kind of coal has so far been encountered which has required the use of the special probe; this coal is precrushed by a hammer mill before being fed to the bunkers.

Hobbing Machine

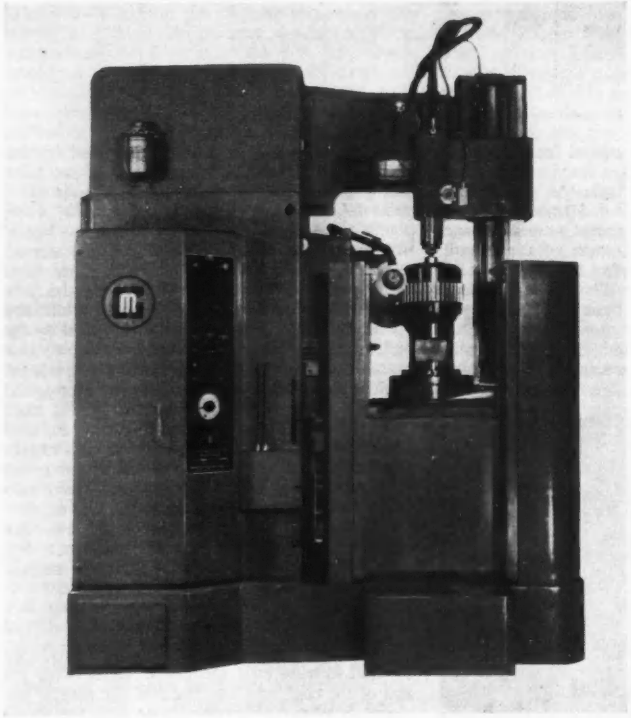
A NEW addition to the "Rigidhobber" hobbing machines made by Churchill Gear Machines, Ltd., Shibdon Road, Blaydon-on-Tyne, Co. Durham, is the "S 1418" machine illustrated below. It has a maximum D.P. of 4 and is designed to cut spur pinions and gears up to 9¾in and helical gears up to 9in. Blanks up to 16in diameter can be cut with a 3in hob and up to 13in using a 6in diameter hob. The maximum height from the work spindle to the centre of the hob arbor is 18in and from the work spindle to the tailstock centre, 34in.

The machine is designed for a fully automatic working cycle, the tailstock, hob slide and workhead all being sequentially controlled. As can be seen in the photograph, all the principal controls are conveniently grouped on a panel at the side of the machine, and from there the operator has a clear view of the work in progress. The required cutting cycle is obtained by setting a rotary selector switch, and a reversing switch for the main motor is used when changing over from climb to normal cutting. Jog buttons are provided for the hob-slide, workhead and tailstock movements to facilitate setting-up. Two microswitches which control the amount of hob-slide movement and the change over from rapid to feed speed can be quickly and easily adjusted. A microswitch in the hydraulic tailstock assembly ensures that the machine cycle will not commence unless the tailstock is correctly positioned.

The index and feed change gears which are mounted in a separate compartment at the front of the machine are all of the same pitch and bore so that they can be interchanged. The eighty-one gears available for feed and indexing purposes range from twenty to 120 teeth (10 D.P.). Drive from the main 7½ h.p. motor is transmitted through vee belts, and a 2½ h.p. motor for the rapid return of the work head after the completion of the cutting cycle is enclosed in the same compartment at the rear of the machine. This rapid traverse motor gives a workhead return rate of 42in per minute, and an electromagnetic brake is mounted on an extension of its shaft.

A new design of hob head fitted on the machine takes hobs up to 6in diameter, and these hob heads are made in two sizes of 3 to 1 and 4 to 1 ratios. The 3 to 1 ratio head gives hob speeds up to 500 r.p.m. and the 4 to 1 head up to 360 r.p.m. These hob heads can be provided with either continuous or intermittent hob shifting mechanism. This intermittent hob shift is effected hydraulically and by it the hob can be shifted in any required increments up to 0·25in per cutting cycle, over a maximum length of 3in. During cutting the hob arbor is clamped hydraulically; when the hob has reached the end of its shaft a warning light is switched on and the hob is wound back to its starting position by hand.

Automatic lubrication is provided for the slides and ways and the main shaft bearings and each time the tailstock is operated a shot of lubricant is applied to each of these members. Automatic oil mist lubrication is provided for the change gears and workhead drive bevels, whilst splash lubrication serves the main indexing worm and wheel, feed shaft worm and wheel and the vertical drive shaft bevel gears. A coolant pump which is belt driven from the main motor shaft gives an adequate flow of coolant to the hob during the cutting operation. The hydraulic pump and its controls are grouped in a single compartment on the machine, and provision has been made for any additions to the hydraulic circuit which may be required for operating special fixtures or loading mechanisms.



Automatic cycle hobbing machine for spur gears up to 9¾in diameter and helical gears up to 9in

Gate-End Box

A NEW gate-end box has recently been introduced by The Belmos Company, Ltd., Bellshill, Lanarkshire. It is designed to comply with the National Coal Board's specification for size 2 gate-end boxes. The equipment, which is illustrated here, is designed for use on a.c. systems up to 650V, is rated at 150A and consists of a flameproof two-compartment welded steel enclosure.

The upper compartment contains three busbars which are rated at 300A, the "on-off-reverse" isolating switch and the auxiliary switches for electrical interlocking. In the lower compartment there are the contactor and the protective and relay equipment; these items are mounted on a withdrawable chassis with plug-in connections for the main and auxiliary terminals. The items mounted on the cover of this compartment are an earth leakage relay, a rotary selector switch, push buttons, an earth fault lock-out indicating lamp and a pilot-earth-fault test switch.

Being d.c. operated, the contactor magnet is suitable for operation down to 65 per cent of the system voltage and the contactor complies with B.S. No. 775 : 1956 for category A4 duty. Supplies for the d.c. magnet are provided by a full-wave bridge rectifier. The operating limits of the contactor are such that the control circuit relay always operates first. A new design of arc chutes which dispenses with blow-out coils is fitted to the contactor. There are overload relays on two poles of the contactor and two-rate time lags are provided, the settings being adjustable between 18A and 180A, with a continuous full-load current of 150A on the higher setting. A link provides means for changeover from one range to the other.

The isolating switch is a load-breaking equipment which is designed to handle currents of 1200A at 650V, 0·25 power factor.

The SGUZ gate-end box shown here is rated at 150A at voltages up to 650V. It is equipped with a load breaking isolating switch and a contactor with d.c. magnet coils. Earth leakage protection and pilot core protection are provided

Earth-leakage protection is provided by a core-balance transformer, the system being designed to trip at 5A or above; an intrinsically safe lock-out circuit prevents the contactor from being operated until the fault is removed and locks out the control circuit on earth fault resistances of less than about 2000 ohms. The existence of a fault is shown by an indicating lamp. The control circuit is designed to comply with N.C.B. Standard Specification P130, and it provides pilot core protection through a half-wave rectifier. The relays in the control circuits are plug-in sealed units.

Meetings on Nuclear Energy

THE Institute of Physics has arranged a conference on nuclear fuel cycles for January 15, 16 and 17, 1958, to be held at the Institution of Civil Engineers, while the Institution of Chemical Engineers is sponsoring a symposium on nuclear energy to be held on Tuesday, January 21, 1958. Details of the former will be available shortly, we understand, and may then be obtained from the Institute of Physics, 47, Belgrave Square, London, S.W.1. A programme for the latter has already been issued. The symposium is to be held at the Hoare Memorial Hall, Church House, Great Smith Street, London, S.W.1, under the initial chairmanship of Sir John Cockcroft, the chair to be taken after noon by Sir Hugh Beaver. The seven papers to be presented are:

"Commissioning and Operation of 'A' Station Calder Works" by H. G. Davey (U.K.A.E.A.).

"Development of Butex Process for Industrial Separation of Plutonium from Nuclear Reactor Fuels" by C. M. Nicholls (U.K.A.E.A.).

"Fission Product Disposal" by K. Saddington (U.K.A.E.A.).

"Nuclear Criticality : A Novel Factor in the Development of Processes and the Design and Operation of Plant" by C. M. Nicholls and A. H. C. P. Gillieson (U.K.A.E.A.).

"The Marcoule Plutonium Plant" by R. Galley (Commissariat a l'Energie Atomique, Paris.).

"Fuel Processing in Homogeneous Aqueous Reactors" by I. Wells (U.K.A.E.A.) and E. Lofthouse (I.C.I. Ltd.).

"Computation of the Performance of Multi-Component Solvent Extraction System : Separation of Uranium and Plutonium from Fission Products by Tributyl Phosphate" by J. A. Williams and J. T. Wood (U.K.A.E.A.).

A film entitled "Criticality" will also be shown. The registration fee is 10s. for members of bodies constituting the British Nuclear Energy Conference and 20s. for others. Forms and other information may be obtained from the General Secretary, The Institution of Chemical Engineers, 16, Belgrave Square, London, S.W.1. Registration forms must be returned by December 31, 1957.

Long Corrugated Aluminium Sheets

At the recent Building Trades Exhibition, the British Aluminium Company, Ltd., announced the availability of very long Rigidal corrugated aluminium sheet which is produced at the company's Falkirk works. New integrated equipment has been installed to manufacture this long, corrugated sheet direct from coiled strip; the plant is designed to produce sheets up to 35ft in length and in thicknesses from 0·028in up to 0·064in (0·22 S.W.G. to 16 S.W.G.). Longer sheets may be made by special arrangement and the length now made available compares with that previously supplied which was limited to 12ft. The accompanying table gives particulars of the sheets currently in production and the weight of a sheet 35ft long. Other profiles, widths and thicknesses, we are informed, will be in production at an early date.

Corrugated sheet production line showing the decoiler, trimming and flattening machines in the foreground, and the conveyor and roll-forming corrugator in the background

Sheet	Width. inches		Thickness		Weight, pound
	Overall	Cover	S.W.G.	Inches	
6T.	33	30½*	18	0·048	83·0
			19	0·040	69·0
10in/3in	32	27†	20	0·036	53·3
			22	0·028	41·5
12½in/3in	39½	36‡	20	0·036	66·5
			22	0·028	51·1

* With one corrugation side lap.
† With two corrugation side lap.
‡ With one and a half corrugation side lap.

The economic advantage of the use of longer building sheets is considerable, since the number of end and side laps for a given area of roof is reduced. Thus, less material is required and both handling and fixing costs are lowered, while lining-up is considerably simplified and erection accelerated. Other advantages of note are improved weather-tightness due to fewer end and side laps, and reduced deflection where the sheets span more than two purlins.

Our illustration shows the production line installed at Falkirk: the plant includes a unit manufactured by the Loewy Engineering Company, Ltd., for trimming and flattening the aluminium strip and for cutting it up into the required length of sheet. This is linked by conveyor to a roll forming corrugating machine provided by Joshua Bigwood and Sons, Ltd., while the English Electric Company, Ltd., has supplied the whole of the electrical equipment. The complete line is 175ft in length.

The Loewy cutting-up line is designed for a maximum speed of 350ft per minute and consists of a stub mandrel decoiler, capable of handling 2-ton coils, followed by a three-roll unbender. Next there is an edge trimmer, with an associated scrap cutter, then a ten-roll flattening machine and, finally, a flying shear. The sheets from the flying shear are deposited on a flat belt transfer conveyor which accelerates them to the maximum corrugating speed of 450ft per minute. From the conveyor the sheets pass on to the transfer and feed table of the corrugating machine, where they are automatically positioned for correct entry into the first corrugating stand. The Bigwood roll forming corrugating machine has seventeen forming stands mounted on a common base. Each stand is driven by a separate 15 h.p. variable speed d.c. motor, the power supply being provided by a motor generator set. The forming rolls are built up on arbors from a number of individual formers and the passline height of each stand is adjustable relative to the adjacent stands.

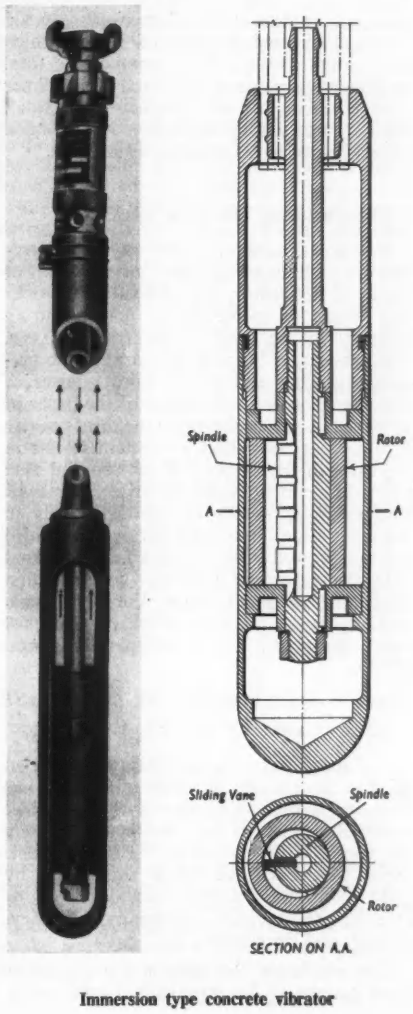
Concrete Vibrators

Particulars have been received from the Sinex Engineering Company, Ltd., 12, Rochester Row, London, S.W.1, of a new range of concrete vibrators of continental design the firm has introduced into this country. At present four immersion vibrators of 30mm to 100mm diameter are made, and two shutter mounting models are available. A sectioned illustration of one of the immersion vibrators is reproduced herewith, together with a drawing which shows its principle of operation. In these equipments a vibrating effect is provided by the out-of-balance force produced by a hollow rotor which turns at from 18,000 to 20,000 r.p.m. A working air pressure of 60 lb to 100 lb per square inch is required for these units.

As can be seen in the drawing, the unit consists of a hollow body down the centre of which there is a firmly supported stationary spindle. The bore of the spindle is connected to the air supply line, and its lower length is supported between two fixed flanges. In the chamber between these flanges is a freely mounted cylindrical rotor. A slot machined in the spindle along the length of the chamber carries a freely sliding vane. Five ports along one side of the slot give free passage for the air to pass into the space between the rotor and the spindle. The flange at one end of the main chamber has a port machined in it, visible below the vane in our transverse section, and air exhausting through this port passes up the outside of the spindle to the atmosphere.

It will be appreciated that air flowing through the spindle ports imparts an epicyclic motion of the rotor round the spindle. As the expanding air at the beginning of each cycle pushes the rotor clockwise the sliding vane is forced back into the spindle. The rotor, contacting the spindle ports, throttles the supply of air as the continued rotary movement opens the exhaust port in the end flange. By the time the exhaust port is fully open the vane is fully extended and a full flow of compressed air is being admitted to the other side of the vane—as shown in the drawing.

The rotor is a free fit in the main chamber and a small back pressure which is maintained enables it to "float" on a cushion of air so that no lubrication is required for the only two moving parts—the vane and the rotor. The smallest model of these vibrators is stated to operate with an acceleration of 150 g, and an amplitude of $\frac{1}{16}$in at a frequency of 20,000 r.p.m., the power absorbed in the vibrator being approximately 1·5 h.p. The largest immersion vibration develops a centrifugal force of 1700 kg at 18,000 r.p.m. The shutter mounting vibrators work on a similar principle and run at 13,500 to 16,000 r.p.m.



Immersion type concrete vibrator

Industrial and Labour Notes

Employment and Unemployment

A report by the Ministry of Labour on the employment situation in Great Britain says that, at the end of October, the number of people in civilian occupations was 23,105,000 (15,287,000 men and 7,818,000 women). This was 7000 less than a month earlier. The principal changes were in agriculture and transport, where the drop during October in the number of people employed was probably to a large extent seasonal. There was also a decline in the number of people at work in the textile industries. On the other hand, the labour force of the engineering, metal goods and precision instruments group of industries increased by 7000 to a total of 2,813,000, which was 1000 below the total returned for October, 1956. In motor vehicle building also, there was a further increase of 3000 in the number of people employed, giving a total of 1,221,000, compared with 1,226,000 a year ago.

The Ministry's report explains that, in the four weeks ended November 6, the employment exchanges filled 141,000 vacancies, the number of vacancies notified to exchanges but remaining unfilled on November 6 being 252,000. That was 22,000 less than a month earlier. In the week ended October 26, there were 38,000 operatives in manufacturing establishments who were working short time. About unemployment, the Ministry reports that on November 11, there were 316,523 people registered as out of work, which represented about 1·5 per cent of the total number of employees, compared with 1·2 per cent a year ago. Of the November total, 301,857 were wholly unemployed and 14,666 were reported to be temporarily stopped.

Manufacturing Industry's Stocks

The Board of Trade says that provisional estimates indicate an increase of about 2½ per cent in the total value of stocks and work in progress in manufacturing industry in the third quarter of this year. This was larger than the increases in the preceding quarter and in the third quarter of last year, both of which were of the order of 1½ per cent. The returns for the third quarter of this year show that a substantial rise in the value of the stocks held by iron and steel companies contributed to the overall increase. The value of stocks of finished goods in manufacturing industry during the third quarter showed little change when compared with the preceding quarter. For the first nine months of this year the provisional estimate is an increase of 8½ per cent, or much the same as in the comparable period of 1956.

Science Careers

In view of the increasing interest in science careers, the Ministry of Labour has prepared a revised edition of the pamphlet on science which is included in the *Careers for Men and Women* series. The pamphlet, which has been published this week by H.M. Stationery Office, includes sections devoted to physics, chemistry, biology, geology and metallurgy.

The emphasis throughout the pamphlet is on careers at the professional level and a university degree course or preparation for the examinations of professional institutions are accordingly recommended as the best training. There are references to the opportunities for scientists in research, design and development, production, testing and inspection, consultation, administration, sales and information services and staff training in industry, as well as in Government institutions and in teaching in schools, technical colleges and universities.

In announcing this new publication, the Ministry of Labour has called attention to the fact that anyone wishing for more personal advice on a scientific career may apply for an interview with one of the professionally qualified members of the staff of the Technical and Scientific Register at Almack House, 26–28, King Street, London, S.W.1. This organisation continues to operate an advisory service on careers in engineering, architecture, surveying and valuation, as well as in pure science and mathematics.

Sea Training for Engineer Officers

Speaking after the launch of the cargo liner T.S.M.V. "Otaro," which is owned by the New Zealand Shipping Company, Ltd., Sir Richard Sneddon mentioned that it was the first British ship in which accommodation was provided not only for navigating cadets but also for engineering cadets. Sea training for navigating officers had long been in operation since the shipowning company had always been a pioneer in this matter and, indeed, he continued, had two special cadet ships where potential navigating officers received instruction by a special staff. This ship represented, he said, a departure from the traditional shore method of training engineers in that thirty engineering cadets would receive training on board from a special staff.

Sir Richard remarked that such a scheme was not easy to bring into being since it was essential to obtain the approval of the Ministry of Transport, which was the examining body, otherwise the trainees under the scheme would not be allowed to take the examination for Certificates of Competency. With the help of the Shipping Federation and after much discussion, the Ministry gave its sanction. In place of the usual four years spent in a shore workshop, he said, the engineering cadets would start their sea careers side by side with the navigating cadets. They would train for two years in the cadet ship and would then sail in the company's ordinary cargo ships for eighteen months to gain practical experience before spending a final year in a shipyard where ships were being built for the company. The new form of entry and training, he concluded, would provide trained engineers well qualified to be in charge of machinery on board ship.

Vacation Training

The latest report of the International Association for the Exchange of Students for Technical Experience records that this year 5934 students have participated in vacation training schemes, an increase of 223 over 1956. In the summer vacation this year twenty countries sent students abroad, the number of "receiving" countries being twenty-one. Great Britain sent 731 students abroad and received 784 from other countries taking part in the scheme. The report comments that the increase in the number of students exchanged during 1957 is small compared with many seasons in the past. In several countries, the exchange has developed so quickly that any further considerable increase cannot be expected, but, the report adds, in other countries it should be possible to make a better contribution to the exchange when outstanding problems concerned with administration have been solved.

This international association has now completed its first ten years. In its first year, there were ten countries which took part in the exchanges, there being 920 students received by 413 industrial firms and organisations. There are now twenty-three member countries of the Association and in them there are 2761 industrial organisations and 401 universities and technical colleges giving support to the exchange schemes. The international association, it should be added, came into being as a result of the initiative taken by the Imperial College of Science and Technology in 1948. In the ten years now completed, 4968 students from thirty-six British universities and colleges have engaged in vacation training at home and abroad in order to gain further experience in industry and commerce. A report on the Imperial College's vacation work scheme, which has just been issued, comments, among other matters, on the increase in the number of British students who have been offered vacation training in Canada during the last few years.

Government Aircraft Policy

In answer to questions in the House of Commons, on Monday last, the Minister of Supply, Mr. Aubrey Jones, stated that the purpose of the inter-departmental committee inquiring into the aircraft industry was to assess the national importance of the industry and to recommend appropriately on Government policy to the industry and, in particular, on the scale on which the Government should support aeronautical research. He did not anticipate that the aircraft industry in Scotland would escape the contraction expected to prevail in the country as a whole. He hoped that skilled personnel released by the industry would apply themselves to the many needs of this country rather than emigrate. The staff of the Ministry of Supply had decreased by 7000 in the current financial year: by the end of it, a reduction of 10,000, say 10 per cent, would have taken place. The staff included 3962 officers of the two senior classes of scientists and 1423 scientific assistants. The Minister believed that it was the general consensus of opinion in this country, the United States of America and among N.A.T.O. countries, that British bombers were superior to American bombers: some of the credit for this should go to the Ministry. Opinion on the Continent of Europe was more favourably disposed to British surface-to-air missiles than to American. Mr. Beswick, informed that no proposals had been made to close the Farnborough department of the Royal Aircraft Establishment, suggested that economies be not made in that department.

Kelvin Power Station

BY OUR SOUTH AFRICAN CORRESPONDENT

Kelvin power station is being built 10 miles north-east of Johannesburg, and, with Orlando power station, will share the bulk of the city's electricity demands. The main items of generating plant are briefly described below. Six 30MW turbo-alternators will be installed in the first section "A" of the station. The first set was commissioned in April last. The section "B" will consist initially of two 60MW sets, the first of which is due to be in service by the end of 1961.

OWING to the steady increase in demand for electricity by the City of Johannesburg, it recently became necessary to construct a further power station, irrespective of the fact that the Orlando power station was completed only as recently as the end of 1955, raising the capacity of that station to 300MW. In addition, the city generating station, with an output of 120MW, brought the then total available capacity to 420MW.

The new station, which has been named the Kelvin power station, is situated some 10 miles to the north east of Johannesburg, adjacent to the Jan Smuts aerodrome. The first turbo-alternator and associated boilers of the Kelvin "A" station were commissioned in April last.

Kelvin power station is being constructed in two portions, designated the "A" and "B" sections. The "A" section will consist of six 30MW turbo-alternators, giving a total capacity of 180MW, and it is anticipated that this portion will be completed by December, 1959.

The "B" section of the station will consist of 60MW turbo-alternators and stage I of the "B" section consists of two sets of this capacity, which are expected to be commissioned at the end of 1961 and 1962, respectively, bringing the capacity of the "B" section to 120MW, which will give a total capacity, with the 180MW of the "A" section, of 300MW. Provision is being made for the extension of the "B" section, as and when required. The cladding of stage I of the "A" section was completed, together with the first three cooling towers, in February of this year, as shown in Fig. 1.

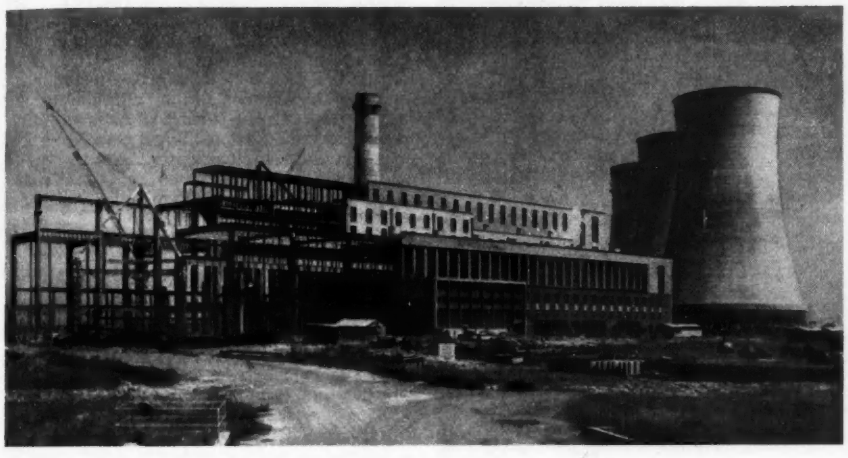


Fig. 1—Kelvin power station; cladding completed of stage I of the "A" station

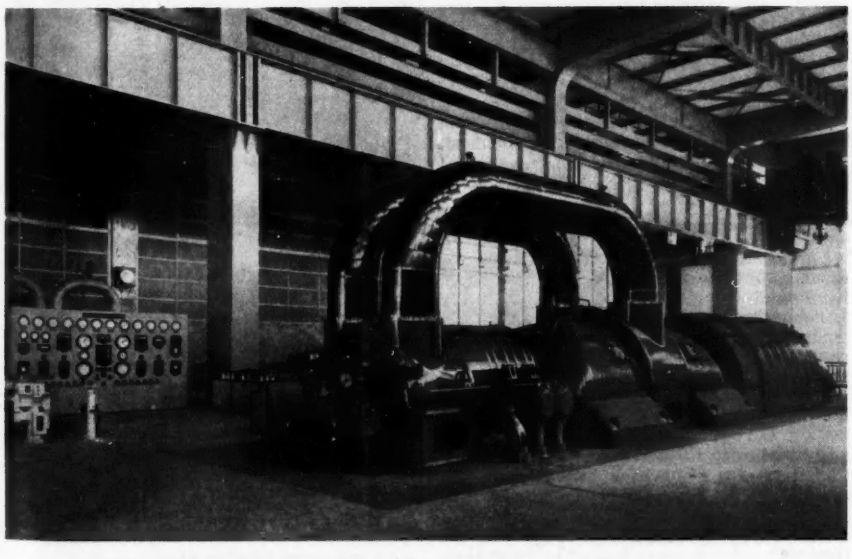


Fig. 2—Kelvin power station; No. 1 generator of the "A" station

In the "A" section steam conditions at the turbine stop valves are designed for 600 lb per square inch, and 850 deg. Fah. Steam will be supplied by eleven Babcock and Wilcox boilers, which are stoker fired, each boiler being rated at 187,500 lb of steam per hour. Each boiler is equipped with twin stokers, the dimensions of each grate being 26ft by 22ft. Superheaters are the one-pass, multi-loop B. and W. type, and the economisers are of the continuous loop type. Draught plant is the usual for this kind of boiler, namely, two fans for forced draught, two fans for secondary air and two fans for induced draught. Coal will be supplied from the Witbank coalfield, of the "mixed" grade, consisting of approximately 50 per cent duff and 50 per cent peas, having a calorific value as fired of 10,750 B.Th.U. per pound.

Coal will be supplied to site by the South African Railways, in trucks ranging from a capacity of 40 to 50 tons. These trucks will be off-loaded in a mechanically operated side tipper of the semi-rotary type, with a capacity of approximately eight trucks an hour. From the off-loading point, coal is handled into the station storage bunkers above the boilers by two independent belt conveyors, each conveyor having a capacity of 250 tons per hour. Coal storage of 20,000 tons is provided outside the station, while each boiler has an individual overhead coal bunker of 400 tons capacity.

Boiler feed water will be handled by the usual multi-stage type pumps, seven of which will be of 360,000 lb per hour capacity and electrically driven, with two steam-driven pumps, each of 375,000 lb per hour capacity.

The turbo-alternators are to be supplied by The General Electric Company, Ltd., of England. The turbines will be two-cylinder impulse machines, with four bleeding points, and running at 3000 r.p.m. Condensing plant is to be supplied by Messrs. Hick Hargreaves and is of the standard twin condenser form, with two extractor pumps and associated ejectors and low pressure heaters. Fig. 2 shows the No. 1 generator assembly for the "A" section.

Generation voltage of the alternators will be 11,000V and this is stepped up to 88,000V in individual generator transformers, before supply to the power station switchyard. Distribution to the City network from this switchyard is again by 88,000V overhead transmission lines.

The proposed "B" station is of a very similar design to the "A" station, the main difference being that steam will be supplied by two pulverised fuel boilers of 550,000 lb per hour steam capacity each, under steam conditions of 950 lb per square inch and 915 deg. Fah. The dust collecting equipment will be of mechanical and electrostatic type. Coal and coal-handling plant will be similar to that being supplied to the "A" station. It is proposed to install three electrically-driven boiler feed pumps, each pump having an output of 660,000 lb per hour; two turbo-alternators of 60MW capacity each, with steam conditions at turbine stop valves of 900 lb per square inch and 900 deg. Fah. Alternator generation voltage is also to be 11,000V, stepped up to 88,000V for supply to the switchyard, which will be common to both the "A" and "B" stations. Contracts have not yet been awarded for the "B" station; therefore, at this stage, no further details of plant for this portion of the station are available.

Completion of Wemmershoek Dam for Cape Town

CAPE TOWN has had its anxieties about its water supply, but these now appear to have been overcome by the completion of the new dam at Wemmershoek. Its capacity is 13,000 million gallons. Work towards the completion of the dam was carried on by night as well as by day, and involved, in addition to the embankment, the construction of a concrete spillway and its electrically operated steel gates, together with the intake works, diversion culvert and treatment plant.

Demountable Truck Bodies

THERE was recently demonstrated in this country the multi-buckets system of Bennes Marrel, St. Etienne, Loire. The Marrel principle is to load a body completely separately from the truck, and pick it up rapidly when it is ready for despatch ; it can then be either set down from the truck still loaded, or the contents tipped out. In applications where the loading and unloading consume much of the time of the vehicle and its driver, very great savings in cost have, we are informed, been effected. In addition, the removable body, which is relatively simple and inexpensive, may take the place of bins or tubs for collecting scrap metal, ashes or small containers.

An all-purpose bucket, with tapered sides that allow two or more to be stacked within one another, is seen in our illustration. The handling gear, here mounted on a Foden chassis, consists of a pair of arms hinged near the rear of the body and operated by double-acting rams ; the ram reactions, which may be much larger than the weight of the bucket, are taken by the side members of the special body, and do not reach the chassis. The centre of the body is a plain tray, with merely a pair of stops near the front which engage the bucket if it moves forward, so that the vehicle can be used as a platform truck. The bucket is not positively located on the body, but, of course, the lifting chains will restrain it if it does slide backwards. When it is required to tip out the contents of the bucket the hooks that can be seen lying under the rear deck are raised; as the bucket is lifted, these hooks engage the shafts, provided on either end of the bucket, and cause it to tilt as it rises. The angle of tip available exceeds 90 deg., so that sticky materials are not likely to remain inboard. At the rear of each side member there is a vertical ram ; these rams, which may be controlled individually, are extended to support the vehicle before raising a heavy load from the ground, a process which would place much more weight on the rear suspension than it has to support when the load is on the body.

In the travelling position the bucket rests upon a steel deck

The hooks are operated by a set of rods from a lever in the cab, and since they retract sideways it is not possible to move them when the body is resting against them. All other movements are powered by a large piston pump driven from a power take-off. The hydraulic system is very simple, the pump delivering to a set of closed centre shuttle valves that direct the oil to one or the other end of each ram ; since the pump, when no valve is open, is delivering against the relief valve, it is recommended in the operating instructions that the required motion be selected before the pump is engaged. The main rams are protected from impressed bending moments by universal joints, and from foreign bodies striking the exposed piston-rods by sliding covers. Pivots are lubricated by hand, both slide and point nipples being used.

There were demonstrated to us the vehicle illustrated, both with the 10-ton body shown and a flat pallet loaded with bricks, and also a 5-ton vehicle which has been used for some months by Leonard Fairclough, Ltd., to carry mixed concrete on the new Preston by-pass. We are advised that no replacement parts at all have been required by the body gear in service ; no oil leaks or deterioration were to be seen, except that the loops on the ends of the chain to pick up the bucket were worn. In the demonstration it appeared that it was desirable to have more than one man to load a bucket on to the vehicle, since when a bucket was at ground level it might be necessary to move the truck a few inches to allow the chains to be hooked on.

Even this small difficulty would not be found with certain of the French vehicles. It will be seen that the Foden has a hook slung between the arms to allow crane duties to be undertaken ; what is known as the three-ram type truck has a third ram under the body moving one of two sheaves on which cables are threaded, these cables leading over pulleys at the ends of the lifting arms and carrying hooks. A vehicle so equipped is able to load itself with very bulky objects, placing them on the body wherever desired in the fore-and-aft direction. The latest refinement, known as the elevated buckets crane, has the arms bifurcated near the top and cables running down to the body from both ends of each arm. With this equipment, the arms are raised part way, so that the two ends of each are at the same height and respectively before and behind the centre of gravity of the bucket. The bucket is then lifted by the cables to the top of the arms, and subsequent further movement of the arms tips the bucket backward ; tipping is at a relatively great height, easily adequate to discharge into railway trucks from a vehicle standing at rail level.

The agents for the Marrel multi-body unit in this country are Aero Maintenance Equipment, Ltd., 100A, Clapham Park Road, S.W.4.

Aerial Ropeways at Cologne

For the German Federal Garden Exhibition which took place in Cologne from the end of April until the middle of October, the firm J. Pohlig Aktiengesellschaft, Cologne-Zollstock, built an aerial cabin ropeway across the Rhine, as well as a chair cableway in the grounds of the exhibition itself. The major installation, the ropeway across the Rhine, of which we show an illustration, was built to allow visitors to circulate between the tramway station near the zoological and botanical gardens on the left bank and a station on the right bank situated near the " Ford Tower " at one end of the " Rheinpark," where the garden show was held.

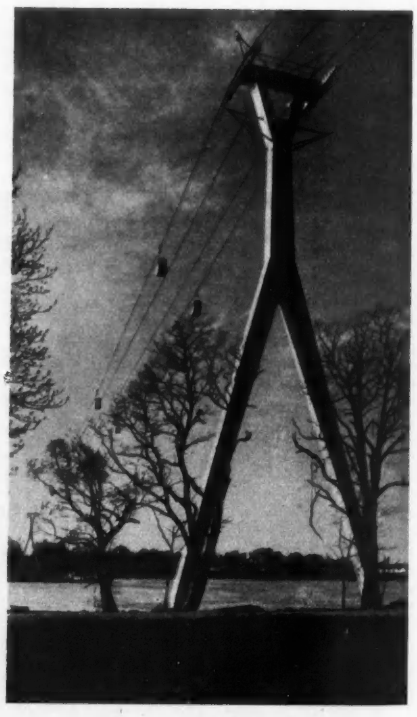
There is a single span, 430m long, across the river with two side spans leading to the stations which are 680m apart. The cabins are suspended from steel wire ropes 45mm in diameter and of closed design, and are hauled by a second rope of 20mm diameter which moves continuously in a closed loop.

Each cabin seats four persons and comprises a steel frame with light alloy skin, with end windows of " Plexiglass " and safety glass side windows. After the passengers have taken their places, the door is closed from the outside by an attendant ; opening from the inside is not possible. Electric light and a ventilator have been provided. The cabin is suspended from a trolley carrying two wheel sets which run on the support cable. Safety on the steeply rising and falling portions of the track is ensured by duplicating the clamping devices which automatically attach the car to the pull rope at the beginning of the journey and release it at the end. Each clamping device, moreover, is designed with a safety factor of 2. In case of malfunctioning of the automatic clamping and unclamping, electrical interlocks immediately cause the installation to stop.

The cableway is powered by either of two 33 h.p. electric motors provided. These are normally supplied from the mains, but an emergency generating set ensures continued operation should the mains power fail.

The two supporting masts are completely welded box-section designs, the one on the left bank being 36·5m tall, and the one on the (lower) right bank 40·5m tall, the layout giving a clearance in mid-stream under the cabins of about 25m. While the supports are free to move on their foundations in the direction of the cables, they must be capable of resisting lateral wind forces and torsional forces about a vertical axis. In order to achieve the required rigidity and at the same time obtain an elegant shape which would fit in well with the landscape, architect and engineers worked in co-operation to produce the present solution. The support wire ropes, which are spaced 7m apart are carried over brackets at the mast top, while the pull ropes run over rubber-lined rollers.

The two foundations of the left-bank mast are spaced at 13·5m distance. On them stand the two 22·5m long mast legs. These legs have a maximum internal section of 1400mm by 1134mm and are of 8mm thick plate. The 1250mm wide flange plates thus overlap 50mm on each edge. This is stated to be advantageous not only from the welding and static points of view,



430m span across the River Rhine of passenger cableway at Cologne, seen from the right bank

but also gives a better appearance, as the edges look sharper and the impression of lightness is emphasised. For access to the top, internal ladders are fitted. The right-bank mast is similarly constructed but its legs spread 15m and its weight is approximately 35·5 tonnes.

As far as possible, the masts were prefabricated. They were brought to the site in four parts. The two legs were welded together on the ground and then raised. After assembling the top section, also on the ground, it was raised into position and connected.

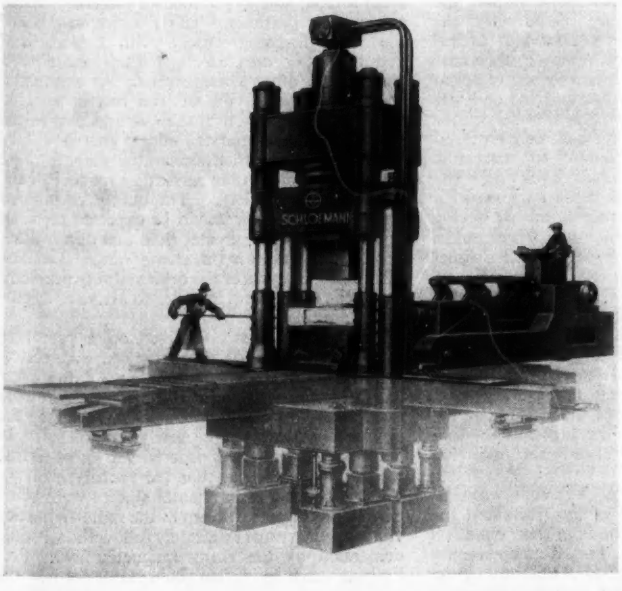
Fifty cabin cars are provided which, at times of peak traffic, leave the stations about every twelve seconds, at distances of 33m approximately. The speed of travel is 2·8m per second, so that in each direction 1200 persons can be carried per hour, making a total capacity of 2400 persons per hour. In 176 days of operation the ropeway has carried 1,350,000 people, compared with 7,800,000 passengers on all German mountain ropeways last year. The largest number on any single day has been 23,000.

The other installation is a 650m long cableway supported on seven 7·5m high single masts, which carries the visitor over the Rhine Park. It has proved almost equally popular with the other, having carried over 1,000,000 passengers so far, with a maximum of 15,000 on a single day. Each of the fifty canvas-roofed tubular steel chairs seats two passengers face to face. The chairs move at 30m intervals on the 24mm diameter combined support and haulage rope, at a speed of 2·5m per second. The rope is driven continuously by a 25 h.p. electric motor, with a Volkswagen engine as a standby, and the cars are automatically clamped to it and unclamped, passengers entering and leaving while the cars are at rest.

1000-Ton Quick-Acting Forging Press

Our illustration shows a model of a 1000-ton forging press made by Schloemann A.G. of Düsseldorf. This electro-hydraulically operated press with automatic planishing device can be used for forging, bending, joggling, straightening, and piercing work. Constructed as a downstroking four-column design with column centres 2240mm by 1250mm, it has a daylight of 2750mm and a stroke of 1400mm, admitting a heavy manipulator for ingots up to 12 tonnes. Length and width of the traversing floor-level table, with no-gap covering, are 1600mm and 1460mm respectively, with a traverse of 700mm to either right or left. The press stands 6850mm above floor level, and has a ram speed for piercing of 500mm per second, and for forging a speed of 100mm per second. Table and saddle shifting device are hydraulically operated. An ejector is fitted in the entablature. It is claimed that damage to the press foundations is completely avoided by the press resting firmly on the feet of its columns without anchoring, stability being ensured by four entablature supports. Conical bushes replace the counter nuts on the entablature so that the columns are protected against injury through notch action at the threads.

The entablature, moving crosshead, top platen and brackets are all of welded steel design. Edging and bending effects on the columns when forging off-centre, are eliminated by providing the moving crosshead with spherically supported guide bushes. All rams and packings, as well as the controls, are stated to be easily accessible, and an automatic central lubricating system feeds all sliding parts.



Model of 1000-ton forging press, showing the entablature supports at the sides of the feet of the columns of the unanchored press. Also shown are the floor level drag plates

Second International Analogue Computation Meeting

The second International Analogue Computation Meeting will take place in Strasbourg, under the patronage of the "Association Internationale pour le Calcul Analogique." Previously announced for the second fortnight in June, this event has been postponed until September, owing to difficulties arising with accommodation. The sessions will take place from September 1 until September 9, 1958. On Sunday, August 31, the participants will be welcomed. An exhibition of analogy computation machines and equipment will be open from August 30 until September 10.

The programme of this meeting will cover the various analogue computation methods (differential analysers, rheoelectrical analogues, network analysers, simulators, special calculators, &c.), and their applications to science and industry.

Owing to the increasing tendency of associating analogue to digital methods, the organising committee has decided to create a new group devoted to electronic digital computation, especially as regards its connections with analogue computation. Those interested in further details are requested to contact Monsieur F. H. Raymond, Secrétaire Délégué Général de l'Association Internationale pour le Calcul Analogique, 138, Boulevard de Verdun, Courbevoie (Seine), France.

Diesel Engine Production

We have received from Sulzer Bros., Ltd., Winterthur, figures for diesel engines under construction and completed during 1957 for ships above 3000 tons deadweight.

At Winterthur, eighty-eight main engines, with a total output of 474,350 b.h.p., are under construction, and twenty-four engines with a total output of 124,900 b.h.p. have been commissioned in the course of this year, making a total of 599,250 b.h.p. For Sulzer licensees, the corresponding figures are 335 main engines (2,184,730 b.h.p.) under construction, and forty-nine main engines (290,900 b.h.p.) commissioned, making a total of 384 main engines and 2,475,630 b.h.p.

Altogether, therefore, 496 engines, totalling 3,074,880 b.h.p., are being built or have been put into service this year. In addition, engines for ships under 3000 tons deadweight, auxiliary engines, stationary and locomotive engines, commissioned or under construction, total 503,640 b.h.p.

U.K.-Community Tariff Agreement Signed

On November 25, the Governments of the United Kingdom and the six member states of the European Coal and Steel Community, together with the Community's High Authority, signed a tariff agreement substantially reducing customs duties on iron and steel products in the United Kingdom and the Community.

Under the terms of the agreement the United Kingdom will reduce its tariffs on a wide range of iron and steel products from the current level of 15–33 1/3 per cent *ad valorem* to a maximum of 10 per cent with an appropriate adjustment of the alternative specific rates.

On their side the member states will apply rates not exceeding those resulting from the harmonisation of their external tariff when the transition period ends on February 9, 1958. These maximum rates will vary between 3 and 12 per cent *ad valorem*.

Signature of the agreement constitutes acceptance by the Governments of the six Community countries and of the United Kingdom of proposals made by the Council of Association between the United Kingdom Government and the High Authority at the Council's sixth session on October 24.

It is a further token of the close association between the Community and the United Kingdom initiated by the Agreement of Association of December, 1954. Coming at a moment when the Community has filled its Treaty obligations to harmonise its external tariffs, it is the first international commercial agreement negotiated by the Community on the basis of its harmonised tariff.

If any of the signatories wishes to increase these customs duties, the agreement provides for prior consultation between them on possible courses of action to avoid the necessity for increased duties, or, if no agreement is reached, on the extent of the increase to be effected.

It is provided that nothing in the agreement should affect the obligations of the signatories under the General Agreement on Tariffs and Trade (G.A.T.T.), and the concessions made under the agreement are therefore extended to all other G.A.T.T. signatories under the most-favoured-nation clause.

Railways and Steel

Continuing its investigation of the economic aspects of trends in the production and consumption of important steel products, the Steel Committee of ECE, Geneva, recently published its report on *Railways and Steel*.* It appears from the report that the demand for steel by the railways is likely to remain at the present level for some years, while the proportion of the total consumption will continue to decline. These overall trends, however, conceal a number of important variations which are outlined in the ECE study, which discusses in detail such matters as the production of railway material and rolling stock; factors affecting demand; official programmes in the railway field, and overseas exports.

In a number of appendices, extensive additional information is given on the production of permanent way material, tyres, wheels and axles and rolling stock; the age structure of Europe's railway-vehicle park; the number of railway vehicles placed in service in recent years; the length of railway networks and the importance of the vehicle parks of practically all the countries in the world, and underground railways. A list of the international non-governmental railways organisations is also given, explaining their aims and the nature of their work, and describing briefly their spheres of interest.

The aim of the report, as was that of its two predecessors, *The European Steel Industry and the Wide-Strip Mill* and *The European Pipe and Tube Industry*, is to foster a more balanced growth of production and demand through better knowledge.

* *Railways and Steel*, Geneva, 1957; sixty-three pages, including thirty-four tables and eight appendices. Available in English, to be followed shortly by a French edition and eventually in Russian. May be obtained from Sales Section, European Office of the United Nations, Palais des Nations, Geneva, or may be ordered through sales agents for United Nations Publications. Price 0.60 dollar, 4s. 6d. sterling, 2.50 Swiss francs, or equivalent in local currencies.

Work of the U.S. Atomic Energy Commission

BY OUR AMERICAN EDITOR

No. III—(*Concluded from page* 843, *December* 6)

RESEARCH and development efforts by Phillips Petroleum, drawing on initial process research at the Oak Ridge National Laboratory, culminated in the design, construction and successful operation at the National Reactor Testing Station of a new facility to produce high-purity radioactive barium. The output is shipped to the Los Alamos Scientific Laboratory for extraction of the daughter product, radioactive lanthanum. The very pure radioactive lanthanum has a specific radioactivity of many hundreds of curies per milligramme, about 10,000 times as great as that of cobalt 60, and is used in biological research.

Progress continued during this report period in developing methods for handling gaseous, solid and liquid wastes. Liquid wastes of low radioactivity, originating in laboratories or in operation of ore processing or fuel fabrication plants, can generally be disposed of successfully with systems and equipment already developed. Harvard University, in co-operation with the Massachusetts State Department of Health, studied on a pilot plant scale what happens to radioactivity dispersed in surface waterways. At Northwestern University, two full-scale studies using radioactive tracers were carried out on the Chicago Drainage Canal in co-operation with the Sanitary District of Chicago and the Illinois State Department of Health. Northwestern University, in co-operation with the Vicksburg Water Experiment Station, of the Corps of Engineers, Department of the Army, also carried out a tracer investigation on a scale model of the Savannah River. Model studies will provide a valuable tool for proposed studies of the fate of radioactivity discharged into tidal estuaries—a study of direct interest to the nuclear-powered ship programme. Such an investigation for New York Harbour was initiated with the Chesapeake Bay Institute of Johns Hopkins University and the U.S. Coast and Geodetic Survey.

The Commission continued its efforts to develop more economical and more permanent methods than tank storage for handling and disposing of highly radioactive liquid residues from chemical processing plants. This remained the major technological problem in disposal. To date, approximately 65,000,000 gallons of high-level liquid residues containing millions of curies of radioactivity have been placed in tank storage. Planning was initiated for a facility at the Idaho Chemical Processing Plant to investigate on a prototype scale one method now under study for fixing residues in a stable, solid form preparatory to storage or burial in selected areas, i.e. conversion of aqueous residues to a solid oxide form by intense heating. Conversion to a solid oxide form of liquid wastes containing high salt concentrations, such as aluminium nitrate waste from processing uranium-aluminium alloy fuels, is in itself a method as well as a useful step in an ultimate disposal system. Such a system would also involve leaching of solid oxide with water or weak acid followed by fixation of the leachate in clay or some other material. Based on the results of discussions with geological and geochemical groups representing the National Academy of Science, National Research Council, U.S. Geological Survey, industrial organisations and others, preliminary investigations were started on the possibility of direct disposal of highly radioactive liquids to salt formations. Other specific geologic formations also were proposed for investigation. Studies were conducted at the Oak Ridge National Laboratory to utilise the decay energy available in the residues to produce temperatures required for self-sintering of a mixture of the waste material and natural earth in a specially prepared pit, thereby forming the material into an insoluble mass.

Physical Research

High-energy physics continued during the first six months of 1957 to command an important share of research effort in the atomic energy programme. Challenging new theories of fundamental physics were being tested. Declassification of further information in the field of controlled thermo-nuclear research was under study. The Commission authorised the design and construction of the Model C "Stellerator," a large experimental device for research in controlled thermo-nuclear reactions, to be constructed at Princeton University.

During this report period, the transfer of the 32 MeV proton linear accelerator at the University of California Radiation Laboratory to the University of Southern California was approved by the Commission. The transfer will release space at the Radiation Laboratory for expanding needs and will provide the University of Southern California with a machine for education, training and research purposes. The two most powerful particle accelerators in operation in the United States, the cosmotron at the Brookhaven National Laboratory and the bevatron at the University of California Radiation Laboratory, experienced emergency shut-downs during the last two weeks of January. Prior to these shut-downs both machines had achieved record beam outputs and were under heavy demand from many important research projects. Because of this, both laboratories assigned all available manpower to the repair jobs. To minimise the loss of total operating time, some planned improvements that would have required future shut-downs were made during the emergency.

The cosmotron was shut down when a short circuit in a magnet caused a fire which damaged the magnet insulation. On dismantling, it was discovered that a fracture near the end of one magnet bar had caused the short circuit. It was known that heavy mechanical stress on these copper bars caused some mechanical motion, but it was believed that the clamps holding the bars would prevent damage. Apparently, the motion work-hardened the copper and caused the fracture. To determine whether other bars might fracture, the vacuum chamber was removed from an undamaged quadrant and the coil was excited separately to measure the deflections that occur. In addition, some bars were removed for metallurgical examination to determine whether microscopic cracks had developed. The bars that failed as well as those bars showing wear were replaced with a redesigned bar having greater thickness at the bend and a larger radius of bend. Along with the repair of the magnet bars, new adjustable "kicker" bars and a new coil clamp were installed. The kicker bars wedge the back coil tightly against the back of the gap and are adjustable from outside the cosmotron magnet. The original kicker bars could be adjusted only by removing the vacuum chamber, a very time-consuming operation. The new coil clamp reduces the motion of the coil to less than one-half the previous motion. The chance of a similar shut-down occurring was thus lessened greatly.

The bevatron at Berkeley, California, was shut down by a working loose of the rivets and the iron brackets in the shrouding that conducts cooling air to the magnet. The rivets apparently came loose after being stressed repeatedly by the pulsed magnetic field. The laboratory made a thorough study of the rivet failure and the rivets are being replaced with non-magnetic ones. The repair job, which involved dismantling of approximately three-quarters of the machine, was completed in July. The recent installation of a "wipe-off" target increased the amount of research data that can be collected by the bubble chamber group at the bevatron. This target scrapes off approximately 5 per cent of the main beam, leaving the remaining 95 per cent for other experiments. This arrangement makes it possible for the bubble chamber to record events with every pulse of the bevatron without hindering any other experiments.

The Commission authorised the purchase and installation of research accelerators by four universities during this report period. A high-voltage engineering tandem-style Van de Graaff accelerator was authorised for the University of Wisconsin. This machine will be housed in a building provided by the university. It will open the energy range from 6 to possibly 12 MeV to exploration in a manner similar to that in which the lower energy range has been explored. Cyclotrons have been working in this range, but with neither the resolution nor flexibility of which the tandem Van de Graaff is capable. The University of Wisconsin was selected because the research group is especially competent in the field of research with a Van de Graaff machine. The Commission also authorised the purchase and installation of a 3 MeV electrostatic generator at Johns Hopkins University. This machine will enable the research group at Johns Hopkins to continue making significant constributions to physical research that are of interest to the Commission. The nuclear physics group at Johns Hopkins University has a 1 MeV accelerator which was built before 1947 and now is obsolete. The machine has been operating less than 50 per cent of the time, because of the necessity of repairing worn parts, and maintaining an inadequately built vacuum system.

In addition to these two machines, the Commission authorised the purchase of two 3 MeV Van de Graaffs for installation at the Case Institute of Technology and the University of Maryland. Case Institute will house the machine in a new building with greatly expanded space for research. The Institute will add several members to its nuclear physics staff and broaden the scope of its research programme. The University of Maryland can provide space for its new accelerator and for establishing a new centre for nuclear physics research by minor modifications of space already available. The University has added several members to its staff for nuclear research work, and made arrangements for the temporary use of accelerators at the Naval Research Laboratory and the Carnegie Institution of Washington.

The Argonne National Laboratory continued studies on the design of a 12,500 MeV proton synchrotron, able to produce all presently known sub-nuclear particles. The magnet will be of the weak focusing variety, with a guide field about 50 per cent stronger than those used currently in other synchrotrons. As a result, a very substantial saving of iron can be effected as well as a reduction in the size and cost of the magnet shelter. Studies indicate that it will be possible to build this accelerator magnet more easily and rapidly than any other magnet of the weak focusing variety. The output of protons from the accelerator would be expected to be an order of magnitude greater than that of any other existing accelerator in this energy range. Detailed theoretical analyses of the orbit stability problems have been carried out in order to arrive at appropriate parameters.

Construction was completed on a prototype master oscillator for the proposed accelerator. A preliminary hook-up was made of the intermediate stage amplifier for the synchrotron. Drawings for the prototype model of the accelerating cavity are nearly completed. In addition, Argonne has ordered 980 kg of ferrite, which will be used to tune the prototype cavity. Theoretical and experimental studies were being carried out on the problem of the radio-frequency voltage which must accurately follow the schedule demanded by the rising magnetic field. Preliminary engineering studies were under way on a variety of subjects such as vacuum chamber design, power and water requirements, foundation stability, magnet power supply, structure

designs and cost estimates. The theoretical group also continued studies of less conventional injection.

In this reporting period, experiments in methods of radio-frequency acceleration were carried out, using a model of the Midwestern Universities Research Association (MURA) radial sector Fixed Field Alternating Gradient (FFAG) accelerator. Previously this machine had used betatron acceleration. The experiments showed that the methods proposed by MURA for accelerating and storing particles in FFAG accelerators were feasible. In view of these results, it would be possible to produce circulating beams of accelerator particles much larger than in pulsed accelerators. Such beams have applications in high energy physics, and MURA has proposed that they be used to perform experiments directly in the centre of mass systems by causing collision of beams that have been accelerated in opposite directions. A new FFAG accelerator model was being designed by MURA to produce such a high current in order to test various plasma effects predicted. The fixed field alternating gradient system has a magnetic field configuration in which the magnetic field is kept constant in time during the acceleration process and the average magnetic field varies periodically with the angle between the field and the machine axis. Ions are injected in the weak region of the field, and accelerated to the stronger region. The configuration uses radio-frequency fields to achieve the required focusing for particles as they are accelerated. This system is in contrast to that of a cyclotron in which the field is constant in time and does not vary with the angle, and from that of the cosmotron or bevatron accelerators, in which the field, in addition to being a complicated function of space, also varies in time. The main advantages of the FFAG system are that much higher flux densities of particles in a more strongly focused beam will be possible.

Instruments have been built at many Commission laboratories for determining the energies of neutrons by directly measuring their velocity and hence their energy. The instruments measure the velocity by producing the neutrons, a batch at a time, and measuring the elapsed time for a given batch to traverse a measured distance from neutron source to neutron detector. The unit of time measurement ranges 5 to 10 thousand-millionths of a second and the elapsed times measured range from 2 ten-millionths of a second to a millionth of a second. The distances over which the velocities are measured range from 3ft to 20ft. These new instruments are different from the neutron choppers used in connection with a nuclear reactor. In that case, the chopper interrupts a continuous beam of neutrons from the reactor. In the new instruments the neutrons are produced through a reaction with the ion beam of a Van de Graaff accelerator or synchro-cyclotron. The neutron batches are produced by pulsing the beam of the accelerator. Adequate pulsed beam currents are thus available for neutron producing reactions.

The instrument at the Oak Ridge National Laboratory is being used to study how neutrons interact with nuclei, and to study neutrons produced in nuclear reactions. One particular application which is new is the utilisation of the reactions that occur when a lithium 7 target is bombarded by a proton, resulting in beryllium 7 with discharge of a neutron ($Li^7+p \rightarrow Be^7+n$). This reaction is used as a source of unmoderated neutrons for "transmission spectrometry." This new approach employing unmoderated neutrons for time-of-flight is useful for studying neutrons in the 1 keV to 20 keV energy range where it has been difficult to obtain accurate energy measurements.

At the Argonne National Laboratory a method was developed using a continuous flow of gas to make a very rapid chemical separation of either of the halogens, bromine or iodine, from other fission products of uranium 235 produced by irradiation with thermal neutrons. The method made possible the identification of certain emitters of delayed neutrons formed from halogen fission products which have a short half-life. As in all other delayed-neutron events, the half-life is the period required for the beta decay of the nuclide's immediate radioactive ancestor, the neutron being emitted at once after the formation by this process of the unstable neutron-emitting nuclide. Two hitherto unrecognised delayed-neutron emitters were found in the experiment. One is krypton 88, formed by the beta decay of bromine 88 with a half-life of 15·5 seconds. The other is xenon 138, formed from iodine 138 that decays with a half-life of 5·9 seconds. Krypton 88 and xenon 138 are the first nuclides with both even atomic number and even neutron number, formed in this way, that have been found to be unstable neutron emitters. A study of the mass-energy relations in these reactions indicated that such even atomic number-even neutron number nuclides are, however, as likely to be neutron emitters as are the even atomic number-odd neutron number nuclides previously identified.

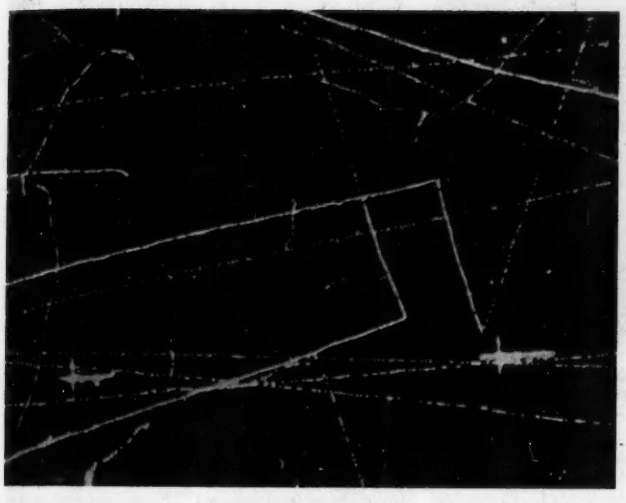
Progress was made in the study of properties of elementary particles during this report period. The new discoveries were inspired by theoretical work done by Professor Tsung Dao Lee, of Columbia University, and Professor Chen Ning Yang, of the Institute for Advanced Study at Princeton University, while they were guests at the Brookhaven National Laboratory. They developed a theory based on "non-conservation of parity" and they suggested certain definitive experiments that could test the prediction of this theory. The experiments consisted of searching for a predicted difference in the number of particles emitted in the direction of polarisation, and those emitted in the opposite direction, for certain cases of radioactive decay.

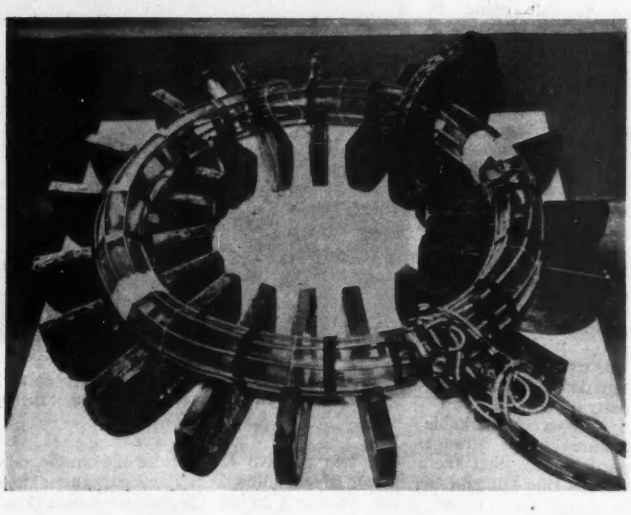
The principle of parity might be explained by an analogy: assume that one motion picture camera is photographing a given set of actions and that another camera is simultaneously photographing the same set of actions as reflected in a mirror. If the two films are later screened, a viewer would have no way, according to the principle of parity, of telling which of the two was the original, and which was the mirror image. The recently completed experiments indicate that there is a way of determining which is which. Contrary to the former theory, some subnuclear particles are not symmetrical in their reaction to nuclear events. Instead, they show a tendency in certain systems to prefer certain directions. This discovery does not appear to require a basic revision of nuclear theory but it may help to explain certain phenomena noted in the behaviour of fundamental particles.

The nature of the interaction between particles in the nucleus, to a large extent, is not well understood, and this represents the central problem of physics to-day. The Commission and its staff have followed closely the combined efforts of the theoretical and experimental physicists in this field. On April 1, eight leading physicists briefed the Commission and its staff on the significance and progress of their work.

The Brookhaven National Laboratory contributed to the experimental evidence for this important development as has work at other laboratories. The tracks of disintegrating mu-mesons from the cosmotron were observed in a liquid hydrogen bubble chamber and it was found that about 30 per cent more electrons were emitted in a backward direction from the mu-meson than in a forward direction. It was discovered, moreover, that the gamma radiation produced by electrons from a radioactive source when they are stopped in matter, the so-called "bremsstrahlung," has a net circular polarisation. This is a direct result of the newly recognised fact that these electrons have their spin axes preponderantly aligned generally parallel along their paths, but pointing in opposite directions. The theory of this interesting effect now is being worked out by theoretical physicists at Brookhaven.

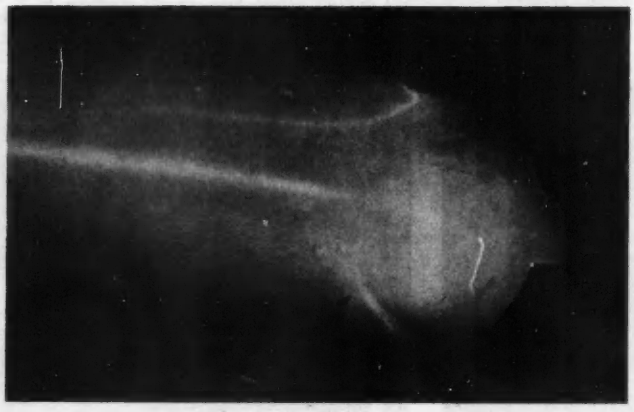
The analysis of cloud chamber experiments performed at the cosmotron at the Brookhaven National Laboratory which established the existence of a so-called "strange particle," the long-lived theta-two meson, continued despite the shut-down in late January. The photographs of cloud chamber events, taken before the shut-down, were studied and two pictures of





(Left) Fragment of a hydrogen bubble photograph showing, among other tracks, two pi-mesons coming from the left, each decaying into a mu-meson (short heavy track at about 90 deg.), and then decaying into an electron (thin dotted track). (Right) Discharge tube of a "Perhapsatron" at the Los Alamos Scientific Laboratory with half-assembled iron cores and primary windings attached to the toroidal glass tube

special interest were found. One shows an interaction of a theta-two that produces a positive K meson, while the other one shows an interaction producing a negative sigma hyperon. According to a successful description of strange particles, K mesons and hyperons are distinguished from pi-mesons and nucleons by non-zero values of a new quantum number called " strangeness." The theta-two meson is produced with positive strangeness. The same theoretical considerations which lead to the view that this meson exists lead naturally to the view that it has mixed positive and negative strangeness. Since the positive K meson has positive strangeness and the sigma minus has negative strangeness, this prediction is now verified. The " strangeness " concept and " strangeness numbers " grew out of the discovery of a large number of new particles in the late 1940s, whose lifetime, though short by ordinary standards, was so long on the nuclear time-scale as to be entirely inexplicable by any theory existing at that time. Physicists began to refer to these new particles as " strange " particles. In 1953, Dr. Murray Gellmann devised a scheme in which he numbered or labelled these new particles with a series of " strangeness numbers," so that it could be determined which particles would be produced under certain conditions and which particles would not be produced under the same conditions. To some degree this scheme is analogous to the periodic chart of the elements. It was found that strangeness is conserved when particles interact to produce new particles, but that it is not conserved when particles simply decay into other particles. The strangeness concept thus describes a new property of matter.



Photograph taken at the Los Alamos Scientific Laboratory showing the " pinch " in xenon gas in a " Perhapsatron " torus

Another remarkable feature of the strange particles was that there were two positive K mesons (the tau and the theta), which differed by a quantum number which physicists called " parity," but which otherwise were very similar. General theoretical ideas, since discovered to have been erroneous, showed that these two K mesons could not have exactly the same lifetimes, even though qualitative experiment already had shown that their lifetimes were similar. At the University of California Radiation Laboratory, the lifetimes of the tau and the theta mesons were carefully measured to be the same within 4 per cent. It was the surprising equality of lifetimes which led Lee and Yang to suggest that ideas about parity might be wrong. It since has been shown by experiments of major importance that this indeed is the case and that parity is not " conserved " in slow decay processes, contrary to the opinion held by physicists for decades.

Further investigations of the production of strange particles were made at the Brookhaven National Laboratory. Measurements of the production of strange particles by negative pi-mesons in a liquid hydrogen bubble chamber were interpreted to mean that hyperons and heavy mesons are produced within a small core at the centre of the proton, which has a radius much smaller than that within which pi-meons are produced. High-energy positive pi-mesons were passed through a bubble chamber and it was established that positive pi-mesons, as well as negative pi-mesons, can produce hyperons and heavy mesons in interactions with protons. The question of whether neutrons and protons are distributed uniformly throughout a nucleus such as lead, was answered by measuring the absorption of 700 MeV positive and negative pi-mesons. At this energy, negative pi-mesons are absorbed mainly by protons and positive pi-mesons mainly by neutrons. Since positive and negative pi-meson absorption cross sections were found to be equal it has been concluded that protons and neutrons are distributed similarly throughout the nucleus.

Computer Research

Recognising that advances in the field of high-speed electronic computation have had a large impact on atomic energy research, the Commission authorised a programme to encourage and foster research in the design, development and use of modern high-speed, digital computers. The initial phase of the programme includes a study by the Digital Computer Laboratory of the University of Illinois to test the design of a computer of greater capabilities than those at present available. The laboratory will thus put to test theories and research arising from the experience gained in operating the digital computer, ILLIAC, over past years. The Rice Institute in Houston, Texas, will construct a modified version of the Los Alamos Scientific Laboratory computer MANIAC II. It is expected that this computer will be a nucleus for a centre devoted to computer research. New York University is operating a computing facility for the use of Commission contractors and providing a research team in applied mathematics to attack problems in the atomic energy field. In support of this work and to provide greater capacity the Commission has authorised the rental of an International Business Machines 704 computer to be installed in the expanded quarters of the university. An applied mathematics division was formed at the Brookhaven National Laboratory which will provide expanded computational services for the laboratory programme. The construction of a digital computer of the MANIAC II class is well under way. A primary use of the machine will undoubtedly be in the high-energy physics programme for the studies of accelerator design, and for the analysis of experimental data and theoretical studies.

Controlled Thermonuclear Research

Representatives of the A.E.C. met with officials of the United Kingdom in June to undertake further studies of declassification of information on research in the field of controlled thermonuclear reactions. In February, approximately 460 persons attended a meeting at Berkeley, California, to review recent developments in controlled thermonuclear research. At the same time, the Commission encouraged the publication of unclassified articles in scientific journals and Commission reports to assist the public, including industry, in keeping abreast of those aspects of the programme which can be described in open literature. As announced previously, the Commission sponsors major experimental programmes at Princeton University, Los Alamos Scientific Laboratory, and the University of California's Radiation Laboratory, Berkeley and Livermore, as well as smaller projects at the Oak Ridge National Laboratory, New York University, and several other university and industrial sites. All these efforts are directed toward developing a method that will achieve a controlled release of energy from nuclear fusion so that the energy can be utilised for the production of electric power.

The nuclear reactions that are most promising for a reactor operated by controlled fusion are those involving two isotopes of hydrogen, deuterium (D) and tritium (T), and helium (He). These reactions are :

(*a*) $D+D \rightarrow He^3+n+3{\cdot}25$ MeV Energy.
(*b*) $D+D \rightarrow T+p+4$ MeV Energy.
(*c*) $T+D \rightarrow He^4+n+17{\cdot}6$ MeV Energy.
(*d*) $He^3+D \rightarrow He^4+p+18{\cdot}3$ MeV Energy.

Reactions (*a*) and (*b*) are of great interest because they involve only deuterium, which exists in ordinary water in sufficient concentrations to permit its isolation. These two are alternative reactions that occur with roughly equal probability. Reactions (*c*) and (*d*) are of interest because of their high energy yield and also because they involve reaction between products of reactions (*a*) and (*b*). Tritium now is obtained by being manufactured in a nuclear reactor. The energy release per fusion reaction—3·25 MeV to 18·3 MeV—is appreciably less than the 200 MeV released in fission. However, if the energy released per unit weight is calculated, the energy yield per unit in the fusion process is slightly greater than in the fission process. The real interest in the fusion process arises, however, from the fact that, if a fusion reaction can be achieved under control, the world will have an energy source virtually without limit. There is enough deuterium in the ocean water to provide all of mankind's power requirements for millions of years.

Formidable difficulties stand in the way of developing controlled thermonuclear reactors. The first difficulty is producing the exceedingly high temperatures of hundreds of millions of degrees required to give the particles sufficient energy for the fusion reactions to occur. It has long been known that useful fusion power cannot be obtained by merely bombarding a target with any known charged particle. Even in very favourable cases, the chance of a nuclear reaction occurring before the charged particle is brought to rest is very small. However, when a hot gas is confined at temperatures of 100 million deg. or more, the probability of a nuclear reaction occurring becomes greater. For nuclei to undergo fusion, they must be brought sufficiently close to one another so that their nuclear force fields may interact. Since the nuclei are all positively charged, they repel each other strongly. To overcome this force of repulsion they must be made to collide with one another at rather high velocities. Since the chances for the nuclei bouncing away from each other far exceed the chances of the fusion process occurring, the nuclei must be confined in some region and caused to approach one another many times, until fusion eventually does occur. This condition of having the particles in a confined region, and moving at high velocities with respect to one another, corresponds to having the deuterium at temperatures higher than those in the interior of the sun, which will vaporise all materials.

Only extremely light elements—those of low atomic number—can be considered as possible fuels in fusion reactions. Part of the reason for this is that the force of repulsion increases with the atomic number of the interacting nuclei—representing the number of protons in each nucleus. Hence the temperature required to overcome these forces of repulsion increases very appreciably with the mass number of the element used. It is for this reason that the isotopes of hydrogen are particularly interesting. Other elements with higher atomic numbers are not out of the question as possible fuels, but they would require even higher temperatures. Another difficulty that confronts those developing a controlled thermonuclear device is making the reaction self-sustaining like a fission chain-reaction, i.e. keeping the device at a temperature at which the system will remain in a steady state and not cool off. At these extremely high temperatures, the only matter that can exist is wholly ionised gas. Such a gas is called a " plasma." This plasma radiates energy at a very appreciable rate. No isolated plasma can remain at a high temperature if it gives off energy faster than it

generates it. Under conditions of practical interest, when the temperature is increased, the rate of nuclear reaction rises more rapidly than the rate of radiation. Accordingly, there is a minimum temperature below which the reaction cannot sustain itself by generating more internal energy than it radiates. This so-called "ignition temperature" turns out to be independent of the density of the plasma. For the deuterium-deuterium reaction this temperature is approximately 400 million deg. For the deuterium-tritium reaction it is somewhat lower.

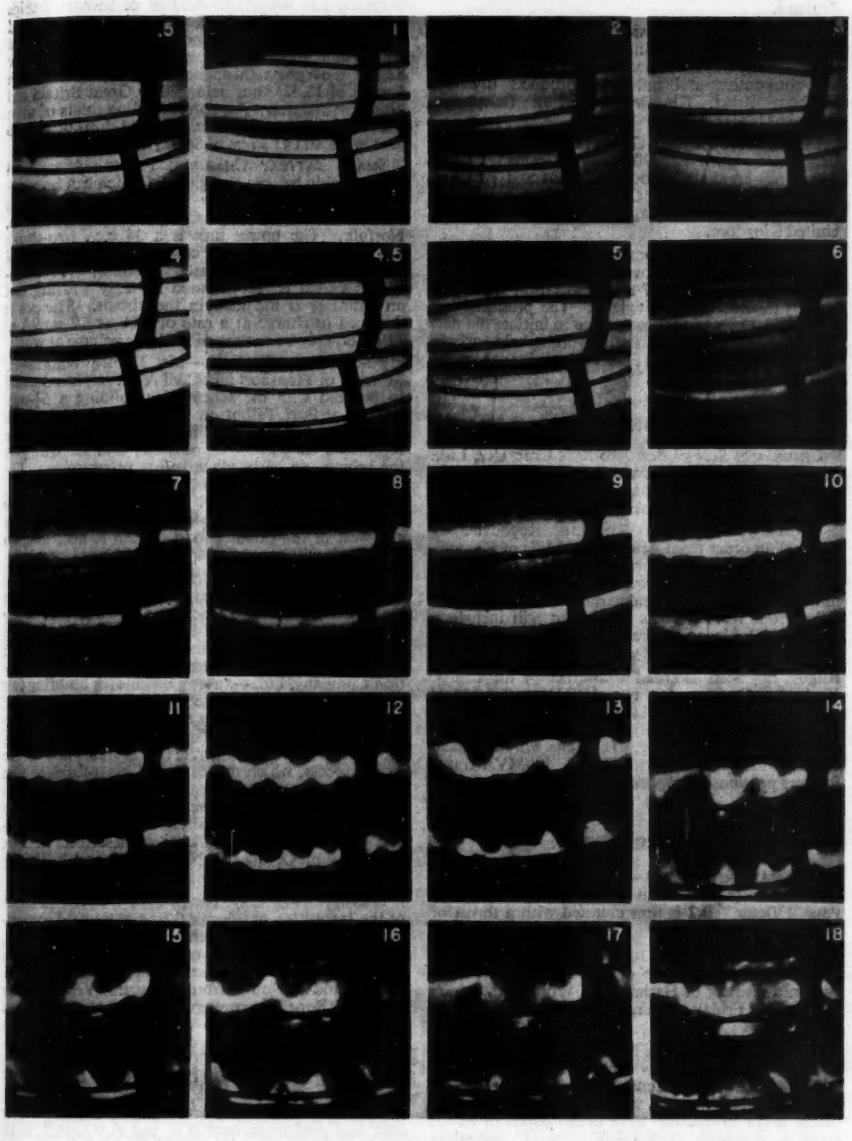


Image converter pictures showing the birth, life and death of a "pinch" in the "Perhapsatron." The horizontal black lines are primary windings and tape holding these windings in place can be seen. The lower part of each picture is a view from underneath the torus as seen with a diagonal mirror. The time from the start of the discharge in microseconds is given on each picture

Providing adequate confinement at such temperatures for a sufficiently long period of time so that an appreciable fraction of the nuclei can undergo fusion is another problem. Clearly no materials can stand up to these enormous temperatures; hence, some other means of confinement of the plasma must be found. It is known that the gravitational forces of the sun prevent the plasma from escaping from the hot region of the sun. Gravitational forces are much too weak to be useful in developing controlled thermonuclear devices on earth. It is possible, however, to use magnetic fields to confine the plasma and to prevent it from vaporising the walls of the reaction chamber. If a group of charged particles of the plasma are in a region in which there is no magnetic field, the particles will move in straight lines until they strike one another or until they eventually strike the walls of the reaction chamber. If a magnetic field is applied, the paths of these same particles will no longer be straight, but will be bent into tight spirals. The particles then will move down the magnetic lines of force in a path similar to the spiral threads of a screw. The only way, then, in which a charged particle can move outward toward the container walls is through colliding with other particles. The collision shifts the instantaneous centre of curvature of the particles' path. A strong magnetic field greatly reduces the diffusion of particles across the field. Roughly, they act as if they were tied to a line of force of the magnetic field. However, motions of particles along the lines of magnetic force are not impeded, and special techniques must be invoked to prevent loss of particles from the hot region in this way. One method used to prevent this loss of particles is to produce an endless discharge in a circular tube shaped like a doughnut.

Another problem is that when magnetic force lines are employed as barriers against the escape of the plasma, pressure is built up inside the magnetic lines and the force walls imprisoning the plasma may become unstable. The force lines behave much like rubber bands around a rubber balloon, i.e. they tend to bend inward and let the plasma flow out around them. At the present time, this phenomenon is one of the big difficulties, and scientists in the programme are searching for an adequate solution. The magnetic field must be strong enough to confine the ionised gas at the very high temperature required and the confinement must last long enough for nuclear reaction to take place effectively.

Several groups of scientists in the controlled thermonuclear programme are working with what is known as the "pinch effect." They are trying to regulate the strength of the magnetic field, and to obtain a direct interplay between the magnetic energy and the energy of the plasma in order to improve stability. The pinch effect can be described as the self-constriction of a group of charged particles moving in such a way as to produce a unidirectional current. The effect is based upon the familiar fact that parallel circuits carrying current in the same direction attract each other. In applying this fact to controlled thermonuclear research, the scientists are seeking, through heavy discharges of electricity, to pinch the atoms of the plasma together and suspend them in a thin line away from the wall of the container. Interesting results have been obtained in this particular effort, but much more work will have to be done. Very high temperatures have been produced in pinched discharges, but the time during which these can be maintained, at present, is in the range of microseconds. As yet, the pinch is not fully stable.

The Los Alamos Scientific Laboratory began pinch experiments in 1952, using a toroidal tube with and without an iron core in its early form, and called it the "Perhapsatron." The purpose of the "Perhapsatron" was to study the pinch in a toroidal geometry, with electrical equipment able to maintain currents of 10,000A to 50,000A for longer times—some thousandths of seconds—than had been possible before. For short time studies of the pinch effect, covering a duration of less than five microseconds, straight tubes are used. Such an arrangement, known as the Columbus geometry, is much simpler electromagnetically and has a higher order of symmetry than the torus.

The pinch effect is but one of a number of alternative approaches being pursued in the Commission's controlled thermonuclear programme. Each approach involves different configurations and different mechanisms of plasma heating and confinement. There have been a number of interesting developments at every site of Commission-sponsored research but all the work is still very much in the research stage. All devices built thus far have been designed for research purposes. It is anticipated that many years of intensive work will be required to develop a prototype thermonuclear device which would yield more energy than it would consume. After that, many more years would be required to develop a full-scale device which might have a chance of competing economically with other sources of power.

Universal Transfer Arm

A TRANSFER device of unusual design has been developed by the Planet Corporation, Lansing, Michigan, to simulate all the normal movements of a human arm, wrist and hand. This device, which was described in a recent issue of *Mechanical Engineering*, was developed to replace human agency in a somewhat dangerous transfer operation of hot die castings to a water quench and on into a trimming press. It has five basic motions of gripping and freeing a part, turning, rotating, extending and retracting, and is capable of carrying out up to twenty-five individual movements in one cycle.

All movements are actuated by hydraulic cylinders or motors under the control of solenoid directional and speed controlling valves. The sequence, degree and speed of movements can be prearranged by setting plugs and potentiometers on a master control panel; alternatively the movements can be determined manually by an operator.

Personal and Business

Appointments

MR. J. P. HALPIN has been appointed a director of Renold Chains, Ltd.

MR. GODFREY AUTY has been appointed deputy chief test pilot of Bristol Aircraft, Ltd.

MR. ALEX MOSELEY has been appointed sales manager, south-western region, of A.C.V. Sales, Ltd.

MR. D. G. BALFOUR-OGILVY has been appointed Glasgow area representative of Power Auxiliaries, Ltd.

MR. H. A. JARMAN has been appointed technical sales representative at the London office of Plowright Brothers, Ltd.

PROFESSOR EDGAR W. E. MORATH has been appointed director of research and development of International Plastics, Ltd.

THE GRESHAM-LION GROUP OF COMPANIES has announced the appointment of Mr. P. E. Simmonds, A.M.I.E.E., as Midlands area manager, and Mr. R. M. Nicholson as Northern area manager.

BRITISH ROAD SERVICES has announced that Mr. W. H. Smith, divisional engineer, north western division, has been appointed rolling stock engineer, chief engineer's department, British Road Services Headquarters.

THE BRITISH TRANSPORT COMMISSION has announced the appointment of Mr. H. C. Johnson as general manager of the Eastern Region of British Railways, in succession to Mr. C. K. Bird, who has retired on grounds of ill health.

BOWMAKER (PLANT), Ltd., announces the appointments of Mr. J. G. Roberts as sales representative for the North Wales area, and Mr. R. J. Cooper as sales representative for North and East Gloucestershire, Worcestershire and Herefordshire.

SIMMS MOTOR UNITS, Ltd., has announced that Mr. J. Chapman has been appointed as director and general manager of Horstman, Ltd. Mr. M. A. Hassid has been appointed a director of Simms Motor Units, Ltd., and of certain of the group companies, including Horstman, Ltd.

THE CENTRAL ELECTRICITY GENERATING BOARD has announced the following appointments :—Mr. H. B. Morton, deputy solicitor ; Mr. C. W. A. Priest, A.M.I.Mech.E., chief project engineer, North (North West, Merseyside and North Wales, North Eastern and Yorkshire areas) ; Mr. R. R. Maddock, A.M.I.Mech.E., A.M.I.E.E., chief project engineer, Midlands (Midlands, E. Midlands and S. Wales areas) ; Mr. T. Yule, M.Inst.C.E., M.I.Mech.E., A.M.I.E.E., chief project engineer, London (London, Eastern, South Eastern, Southern and South Western areas).

The board also announces the following appointments of regional directors, from January 1 :—Mr. P. Briggs, A.M.I.Mech.E., North Eastern and Yorkshire ; Mr. R. L. Batley, A.M.I.Mech.E., Midlands and East Midlands ; Mr. A. R. Cooper, M.I.E.E., Eastern, London and South Eastern ; Mr. A. C. Thirtle, A.M.I.C.E., A.M.I.E.E., Southern, South Western and South Wales, and Mr. W. C. Parker, M.I.E.E., North West, Merseyside and North Wales. The Board has also announced the appointment of Mr. H. J. Bennett, A.M.I.E.E., as controller of the London division and deputy director of the Eastern, London and South Eastern Region. Mr. W. J. Rowland has been appointed deputy chief personnel officer, and Mr. E. J. Guinness, deputy secretary.

Business Announcements

MR. A. J. SOMERS has retired after thirty-six years with Borax Consolidated, Ltd.

THE DATA RECORDING INSTRUMENT COMPANY, Ltd., announces that it has taken larger premises at Woodthorpe Road, Ashford, Middlesex.

IGRANIC ELECTRIC COMPANY, Ltd., Bedford, states that its Glasgow office has been moved to 242, West George Street, Glasgow, C.2 (telephone, City 4537–8).

THE INTERNATIONAL PLASTICS GROUP OF COMPANIES' sales department has been transferred from 3, Vere Street, to 24, Gilbert Street, London, W.1 (telephone, Mayfair 9501).

BRITISH UNITED TRACTION, Ltd., states that its administrative and sales contracts staff and drawing-office have moved to 96, Piccadilly, London, W.1 (telephone, Grosvenor 7121).

MEGATOR PUMPS AND COMPRESSORS, Ltd., states that a subsidiary company, Megator Pumps and Compressors Inc., 930, Manchester Avenue, Pittsburgh 12, Pa, has been formed to handle its American business in industrial and marine self-priming pumps.

BLACK AND DECKER, Ltd., has announced the establishment of a new company, Black and Decker (New Zealand), Ltd., in Auckland. The new company will provide a complete repair and maintenance service, and will be managed by Mr. J. Smith-Palmer.

MASSEY-HARRIS-FERGUSON, Ltd., states that it has sold its assets in New Zealand to C. B. Norwood, Ltd., which will in future have the exclusive franchise for the whole range of Massey-Ferguson products, both agricultural and industrial, throughout New Zealand.

WESTINGHOUSE BRAKE AND SIGNAL COMPANY, Ltd., states that since the acquisition of Douglas (Kingswood), Ltd., it has formed a new division known as the automotive and industrial products division, Hanham Road, Kingswood, Bristol (telephone, Bristol 671781).

DEMAG-BAGGERFABRIK G.m.b.H. (22A), Düsseldorf-Benrath, Postfach 90, Düsseldorf, Germany, states that it has appointed Wood, Pritchett and Partners, Ltd., Mechquip House, Goldhawk Road, London, W.12, as its sole selling agent and distributor in the United Kingdom.

THE REINFORCED CONCRETE ASSOCIATION held a meeting at Bristol on November 22 at which it was decided that a branch of the Association should be formed in the West of England. The president has appointed a provisional committee to initiate the new branch. The inaugural meeting will be held early in the New Year. This will be the fourth branch of the Association.

Contracts

CHUBB AND SON'S LOCK AND SAFE COMPANY, Ltd., has received an order for two vault doors for the main strongroom of the new headquarters of the Bank of Montreal, each to weigh over 33 tons.

THOMAS ROBINSON AND SON, Ltd., Rochdale, has received an order from Aftab Flour Mills of Karachi, Pakistan, for a new flour mill capable of milling some 130 tons of wheat every twenty-four hours. The new mill will be sited in the industrial area at Lhandi, 15 miles from Karachi. Its equipment will include a battery of Robinson square sieve sifters.

THE BRITISH THOMSON-HOUSTON COMPANY, Ltd., Rugby, has been awarded a contract by the C.E.A. Yorkshire Division for two 180MVA, 275/132kV auto-transformers for installation at Skelton Grange. This is one of the first two contracts to be placed for transformers of this rating. The units will be banked on the 275kV side with two B.T.H., 120MVA transformers previously supplied.

Miscellanea

BY-PASS PERFORMANCE.—The Rolls-Royce "Conway" R.Co.11 power unit of the proposed Handley-Page "Victor" B.2 is now credited with a thrust of 17,250 lb.

MR. W. STRACHAN, JUNIOR.—It is with regret that we record the death of Mr. William Strachan, Junior, a director of Harland and Wolff, Ltd., which occurred on Friday morning of last week after a long illness.

NEW BUILDINGS AT THE RADIOCHEMICAL CENTRE.—In the article on the new buildings recently opened at the Radiochemical Centre, Amersham, printed in our issue of November 8, we omitted to mention that design and construction were in the hands of E. D. Jefferiss Mathews, F.R.I.B.A., of J. Douglass Mathews and Partners, who was the architect ; Gardiner and Theobald, who were the quantity surveyors ; G. H. Buckle and Partners, who were the electrical and mechanical engineering consultants ; A. C. Aston, B.Sc. (Eng.), A.C.G.I., who was the structural engineering consultant, and James Longley and Co., Ltd., who was the general contractor.

RETICULAR ALUMINIUM-TIN BEARINGS.—A new bearing alloy announced jointly by the Tin Research Institute and the Glacier Metal Company contains about 20 per cent of tin, the remainder being aluminium hardened with from 1 to 3 per cent of copper. The tin constituent has a structure which is reticular within the continuous aluminium matrix—that is to say, the tin has a structure which is itself continuous without disturbing the continuity of the aluminium. Should metal-to-metal contact occur between a shaft and a bearing with this reticular structure there is an immediate supply of tin available at the surface to provide a thin soft layer of tin over the aluminium and thus inhibit surface breakdown. It is claimed that the new alloy combines the strength of a continuous aluminium phase with the tin availability of a comparatively heavy and continuous tin structure, and when supplied in the form of steel-backed bearings it provides a better balance between the opposing demands of high fatigue strength and low rates of wear than other plain bearings. Furthermore, unlike copper-lead bearings, it needs no lead-based overlay plating to keep shaft wear in check. These reticular aluminium-tin bearings can be supplied prefinished, but since they have no overlay plating they can equally well be supplied semi-finished for boring in place.

LLOYD'S WRECK RETURNS.—Lloyd's Register of Shipping has issued the returns of merchant ships totally lost, broken up, &c., for the quarter ended March 31. Steamships and motorships totally lost consequent upon casualty amounted to 49 ships or 82,035 tons gross throughout the world, of which 6 ships of 10,825 tons belonged to Great Britain and Northern Ireland. The corresponding totals of ships condemned, broken up, &c., were 79 ships of 136,626 tons gross and 41 ships of 86,221 tons respectively.

SMALL BATTERY CHARGING PLANT.—A compact and portable battery charging set which can be easily carried by hand is now being marketed by the Wroxham Engineering Company of Wroxham, Norfolk. The power unit is a 34 c.c., two-stroke J.A.P. engine supplying current from a fly-wheel magneto through a metal rectifier. A "no-load" switch is incorporated for easy starting and an ammeter is included in the circuit. The set is designed to charge at a rate of 12A at 6V or 9A at 12V, and may be connected to either voltage at will.

PORT TALBOT BY-PASS.—Mr. Harold Watkinson, Minister of Transport and Civil Aviation, has decided to proceed with the scheme for building a 5¼-mile by-pass at Port Talbot on trunk road A.48 between Swansea and Cardiff. Preliminary work on it is to be completed as quickly as possible, and he will give the scheme an early place in his programme. The by-pass is estimated to cost more than £2,500,000 ; it will start at Groes, skirt the north-east side of the town, cross the River Avon on a viaduct, and then run west of the existing road to join it near Baglan Brook. It will have two 24ft carriageways.

FILM ON HYDRO-ELECTRIC CONSTRUCTION.—The main contractor for the upper stage of the Moriston hydro-electric scheme, which was completed recently for the North of Scotland Hydro-Electric Board, has had a film made depicting the progress of the work and the way it was done. This firm—the Mitchell Construction Company, Ltd.—was responsible for building two dams at the head of the scheme, a connecting tunnel between them and a further main tunnel and an underground power station. The dams were noteworthy for the use of precast concrete facing slabs, and of the Trief process, which makes use of blast-furnace slag to replace part of the cement. All this is explained in the film, and an idea is given of the conditions under which men worked at the site. The consulting engineers for this scheme—which was described in THE ENGINEER of October 5, November 2 and 9, 1956—were Sir William Halcrow and Partners.

PRESSURE VESSELS.—The North-Western Branch of the Institution of Chemical Engineers held a meeting in Manchester on November 19, when two papers, "Problems in the Design of Pressure Vessels for the Calder Hall Type of Nuclear Reactor," by Mr. R. W. Lakin, and "Non-Ferrous Pressure Vessels," by Mr. H. T. Bone, were presented. Mr. Lakin described a steel vessel required to contain a coolant gas at 50 lb to 300 lb per square inch and to enclose a cylindrical graphite core, 30ft to 50ft diameter and a similar height. (The vessel designed for Calder Hall was 37ft diameter, 70ft high, 2in thick, with a working pressure of 100 lb per square inch.) Lloyd's Register code had preference over B.S. and A.P.I.–A.S.M.E. codes because the requirements could be discussed with Lloyd's surveyors and the requirements of the other codes could not be met. The problems of spheres, horizontal and vertical cylinders and the methods of supporting them were described. End closures and the stresses around the openings in the vessel were dealt with and the properties of the thick plates were considered. The inspection of the materials, particularly the welds, was described. Mr. H. T. Bone discussed the uses and fabrication of copper, aluminium and their alloys. Vessels may be designed by B.S. 1500, and the A.S.M.E. code is available for use in design work. The metals and alloys named are not affected by low temperatures. Aluminium vessels must be supported, even against the force of the wind, and they may be enclosed in a mild steel shell as support. The connections and closures to aluminium vessels have full-faced flanges. Soft gaskets are used. The bolts are of manganese bronze, which may be cadmium-plated to prevent electrolytic action. Aluminium vessels may be welded by the tungsten arc, argon arc and gas methods, but the fluxes must be completely removed as they are corrosive. Manganese bronze vessels are cast successfully, but they shrink considerably during casting.

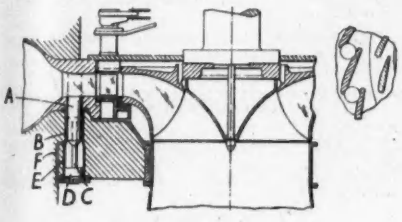
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgement is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

HYDRAULIC MACHINERY

783,798. March 1, 1955.—HYDRAULIC TURBINES, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventor: Paul Werner Seewer.*)

The invention relates to hydraulic turbines in which water passes first into an outer surrounding space and thence through a ring of pivoted vanes for the load control of the turbine and in which an independent system of auxiliary shutters is placed between the surrounding space and the ring of pivoted vanes whereby the complete gate apparatus and rotor



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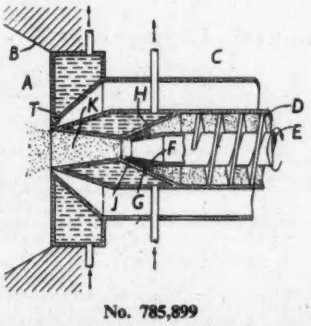
can be isolated from the water for inspection, repair or other reasons. According to the invention, cylindrical sluice valves *A* in a conventional Francis turbine are slidably arranged in cylinders *B* attached to the lower speed ring into which they are retracted in normal operation of the turbine so as to have their end faces flush with the ring, as shown in full lines in the drawing. These cylindrical sluice valves are each connected by means of a rod *C* to a servomotor piston *D* movable in a cylinder *E*, attached to one of the valve cylinders. The pistons *D* are of larger diameter than the cylindrical sluice valves *A*, and, therefore, when the spaces below these pistons are connected, by pipes and control valves not shown, to the spiral casing or any other suitable point of high water pressure, the pistons will raise the cylindrical sluice valves *A* into the position shown in chain-dotted lines, in which position they abut on the upper speed ring and isolate the turbine runner and guide apparatus from the spiral casing. The seepage water contained in the cylinders *E* above the pistons is discharged to drain through conduits *F*. As will be seen from the right-hand view, shallow part-cylindrical recesses may be provided in the flanks of the stay vanes adjacent the cylindrical sluice valves so as to provide a good area seal. These recesses, being part-cylindrical, can be easily machined the same as the cylindrical sluice valves.—*October* 2, 1957.

FURNACE FIRING

785,899. November 11, 1955.—GASIFYING FINELY DIVIDED FUELS, Heinrich Koppers, G.m.b.H., Moltkestrasse 29, Essen, Germany.

The invention is especially concerned with an arrangement with which the preparation of the fuel-oxygen suspension for the gasification can be carried out in a particularly effective manner. In the drawing,



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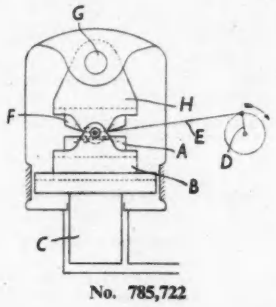
A is the reaction chamber, which is surrounded by refractory walls *B*. Connected to the reaction chamber is a blower *C* which consists of a conveyor worm *D* with a hollow shaft *E* through which the oxygen is conducted. The hollow shaft terminates towards the reaction chamber as a conical section *F*, which forms an annular slot *G* in conjunction with the wall *H* of the worm housing. The conveying velocity of the worm *D* and the free cross section of the annular slot *G* are so adapted to one another that a certain compression of the fuel takes place in the annular slot, this compression preventing rearward passage of oxygen. At the ssme time, however, the compression is also limited in such manner that it is possible for the plug consisting of compressed fuel at the inner rim *J* of the annular slot to be constantly broken up by the oxygen flowing through the shaft. The fuel-oxygen mixture passes into the mixing section *K*, in which is effected a certain further improvement in the homogeneous character of the suspension, but, at the same time, a somewhat higher oxygen concentration obtains in the vicinity of the axis of the mixing section than towards the edge. The suspension then passes into the reaction chamber in the form of a short bushy flame. The walls of the mixing section *K* are formed by a water-cooled jacket and side of the blower device which faces the gasifying chamber also consists of a water-cooled jacket. The surfaces of the cooling jackets, which face one another, are so arranged that they form an annular nozzle through which steam is injected into the reaction chamber to surround the flame and prevents a reaction between oxygen and the gas which is produced, where this is at all still possible.—*November* 6, 1957.

METALLURGY

785,722. April 4, 1955.—DIE FORGING PRESS, Beche and Grohs Gesellschaft mit Beschrankter Haftung, 31, Peterstrasse, Huckeswagen/Rheinland, Germany.

An object of the invention is to provide a die forging press which requires substantially smaller pressure forces for forging given workpieces. Referring to the drawing, a lower die *A* is of conventional construction and is fixed to the table *B*, which is displaceable in a plane guideway on the suitably widened upper end of the ram *C*. Provided near the press is a crank gear *D* which is connected to a motor and which is connected to the upwardly projecting cheeks of the table by two rods *E* so that the table with the bottom die on it can be reciprocated in its guideway by the crank gear. The upper die *F* has a working surface



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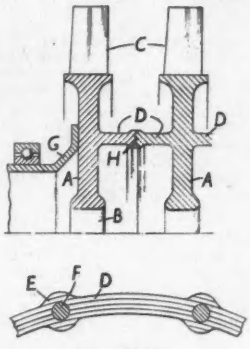
which is curved in an arc whose centre of curvature is the pivot pin *G*. The upper die carried by the lever *H* is adapted to swing about the pin *G*. The lever *H* is also connected to the crank gear *D* by way of the two connecting rods so that, when the crank gear is operated, the upper and lower dies are reciprocated in the same directions and by the same amplitude. For the die forging operation, the heated blank is positioned on the lower die. The ram *C* then moves upwards with a light pressure until the blank is gripped between the dies. The crank gear *D* is then set in operation and the pressure on the ram is increased. During the forging operation the crank gear remains operative, so that the heated blank is, so to speak, kneaded into the cavities of the dies. The pressure acts only on a narrow strip of the upper side of the workpiece, the width of which is chiefly dependent on the radius of curvature of the working surface of the upper die, which moves to and fro over the workpiece during the forging operation. The forging operation is advantageously not carried out in one step but with repeated application or lifting of the ram whilst the dies are reciprocated. The pressure can be produced in any desired manner, but it is essential, however, that it should be capable of being increased during the reciprocation of the dies.—*November* 6, 1957.

COMPRESSORS AND TURBINES

785,002. April 20, 1955.—ROTOR FOR A COMPRESSOR OR TURBINE, Power Jets Research and Development, Ltd., 25, Green Street, London, W.1. (*Inventor: Leonard Islip.*)

The invention is concerned with the type of rotor comprising a number of axially successive discs having annular axially abutting locating faces for centring the discs relative to one another. As shown in the drawing, the rotor comprises a number of coaxial axially spaced rotor discs *A* extending transversely of the rotor axis and each having a central bore *B* and a row of rotor blades *C* secured to its periphery. Each disc has an integral cylindrical extension *D* from each face concentric with rotor axis and radially within the blade roots, each of the end discs having a single extension. As shown in the lower view, the extensions are formed with bosses or enlargements *E* at a number of positions symmetrically



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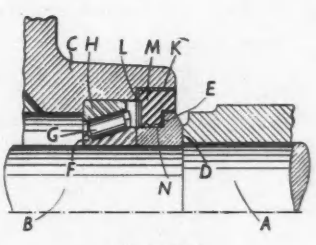
disposed around the rotor axis, and the discs are held together by through bolts or tie rods *F* which extend through clearance holes in these bosses. These bolts merely serve to retain the discs and do not themselves have any locating function. At each end of the rotor there is provided a bearer member *G* for supporting the rotor in bearings. The abutting faces of each pair of cylindrical extensions *D* have annular circumferentially extending ribs or serrations *H*. The flanks of each serration engage with correspondingly tapered flanks of the grooves between the serrations on the other disc. The engaging tapered flanks of the serrations *G* serve to take the axial loads resulting from tightening the bolts and they present a comparatively large bearing area for withstanding the radial crushing loads arising from differential expansion of the discs. The form of the serrations may correspond to any screw thread of generally triangular form. The pitch and number of the serrations will depend upon the loads to be withstood and the amounts of differential expansion of the discs to be allowed for.—*October* 23, 1957.

MINING ENGINEERING

785,711. May 25, 1954.—WHEEL MOUNTINGS FOR MINE CAR AXLES, Richard Dutton-Forshaw, Burtonwood Engineering Works, Burtonwood, Warrington, Lancashire.

As shown in the drawing, the mine car axle *A* has an end portion *B* of reduced diameter, on which the flanged wheel *C* is mounted. Against the shoulder *D* there abuts an L-section distance piece *E* which is fixed on to the axle. Located between the distance piece and a retaining nut, on the end of portion *B*,



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is the inner race *F* of a roller antifriction bearing *G*. The outer race *H* of the bearing is a press fit within the bore of the wheel, and on the inner side of the bearing is counter-bored to provide an annular recess *K*, in which is located a sealing ring comprising an annular, rigid, angle-section outer portion *L* to which is bonded an inner, annular, resilient portion *M*. The outer flange *L* is a tight push fit, within its locating recess, whilst the bore of the resilient portion provides a sealing face *N* which bears resiliently against the periphery of the horizontal limb of the L-section distance piece *E*. The sealing ring is provided with annular recesses or grooves to form a labyrinth packing to prevent outward seeping of lubricant and the inward passage of dust and dirt.—*November* 6, 1957.

Launches and Trial Trips

IRISH SPRUCE, closed shelter deck cargo ship; built by Cammell Laird and Co. (Shipbuilders and Engineers), Ltd., for Irish Shipping, Ltd.; length between perpendiculars 420ft, breadth moulded 62ft, depth moulded to upper deck 39ft, mean load draught 26ft 6in, deadweight 9150 tons; four cargo holds, and a deep tank, one 30-ton, two 8-ton and ten 5-ton derricks, electric deck machinery; three 200kW diesel driven generators; one set of double reduction geared compound turbines, two Babcock and Wilcox watertube boilers generate steam at 450 lb per square inch and 750 deg. Fah. Trial, September 27.

CARRONBANK, cargo liner; built at Belfast by Harland and Wolff, Ltd., for Andrew Weir and Co., Ltd.; length overall 483ft, length between perpendiculars 450ft, breadth moulded 62ft 6in, depth moulded 38ft 6in, gross tonnage 6460; two complete steel decks, five cargo holds, one 25-ton, two 10-ton, twelve 5-ton and two 3-ton derricks, electric cargo winches; three 175kW diesel driven generators; Harland and Wolff two stroke, single-acting, opposed piston diesel engine, six cylinders 620mm diameter by 1870mm combined stroke, 118 r.p.m. Trial, September 27.

LOUIS GIRARD, trawler; built by the Anciens Chantiers Dubigeon for the Chalutiers Malouins; length overall 246ft 1in, length between perpendiculars 223ft 1¾in, breadth moulded 38ft 6¼in, depth 20ft 8in; fish hold 44,000 cubic feet, electric trawl winch; diesel-electric machinery, three 560kW generators driven by eight cylinder, turbo-charged Sulzer diesel engines, each of 950 h.p. at 500 r.p.m., two 950 h.p. propelling motors drive a single shaft through a Messian, 850/165 r.p.m., reduction gear.—Trial, September.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Wed., Dec. 18.—NOTTINGHAM BRANCH: East Midlands Electricity Board's Showroom Theatre, Smithy Row, Nottingham, "The Approved Contractor and the National Inspection Council," E. J. Sutton, 7.30 p.m.

Thurs., Dec. 19.—LONDON BRANCH: Lecture Theatre, Institution of Electrical Engineers, Savoy Place, London, W.C.2, London National Lecture, "Electrical Floor Warming," W. F. Parker, 6.30 p.m.

BRITISH COMPUTER SOCIETY

Mon., Dec. 16.—Northampton College of Advanced Technology, London, E.C.1, "Parallel Programming: A Study of a New Technique in Digital Computer Programming," S. Gill, 6.15 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., Dec. 18.—LONDON BRANCH: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Recent Developments in Electronic Instrument Design," E. Garthwaite and A. G. Wray, 6.30 p.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Dec. 19.—Caxton Hall, Westminster, London, S.W.1, Presentation of Report on Heavy Oil Engine Working Costs and Performance, 1956–57, and Discussion on "Operating Problems," 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Dec. 16.—LIVERPOOL CENTRE: Liverpool Passenger Transport Office, 24, Hatton Garden, Liverpool, 3, "Lighting and Coal Mining," W. E. Mangnall, 6 p.m.

Fri., Dec. 20.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, "New Light Sources," F. Jackson, 6 p.m.

INCORPORATED PLANT ENGINEERS

To-day, Dec. 13.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, "Torque Convertors," A. L. Gattis, 7.30 p.m.

Wed., Dec. 18.—KENT BRANCH: King's Head Hotel, High Street, Rochester, "An Application of Incentives to Boiler-House Operations," K. Bentley, 7 p.m.

Thurs., Dec. 19.—BLACKBURN BRANCH: Golden Lion Hotel, Blackburn, "Some Aspects of Boiler Inspection," W. A. Mills, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Dec. 17.—EAST ANGLIAN SECTION: Lecture Hall, Public Library, Ipswich, Films on "Flow of Metal into Moulds," "The First Four Years" and "Bubble Model of a Metal Structure," 7.30 p.m.

INSTITUTE OF FUEL

Thurs., Dec. 19.—Institution of Civil Engineers, Great George Street, London, S.W.1, "Russian Coal Mining and Fuel Technology," W. Idris Jones, 5.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Dec. 16.—KINGSTON UPON HULL AND EAST MIDLANDS SECTION: Royal Station Hotel, Kingston upon Hull, "The Trials and Maiden Voyage of the Gas Turbine Ship 'John Sergeant,'" J. J. McMullen, 7.30 p.m. ★ WEST OF ENGLAND SECTION: Grand Hotel, Bristol, Films on "The Cornish Engine," "Foothold on Antarctica" and "Controlled Heat," 7.30 p.m.

Wed., Dec. 18.—N.E. COAST SECTION: Stephenson Building, King's College, Claremont Road, Newcastle upon Tyne, "The Trials and Maiden Voyage of the Gas Turbine Ship 'John Sergeant,'" J. J. McMullen, 6.15 p.m.

INSTITUTE OF NAVIGATION

Fri., Dec. 20.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "Admiral Francis Beaufort: His Contribution to Hydrography and Navigation," K. St. B. Collins, 5.15 p.m.

INSTITUTE OF PHYSICS

To-day, Dec. 13.—MANCHESTER AND DISTRICT BRANCH: Bragg Lecture Theatre, The University, Manchester, "The Strength of Materials—with Special Reference to Metals," A. H. Cottrell, 6.45 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

To-day, Dec. 13.—SOUTH WALES CENTRE: South Wales Institute of Engineers, Park Place, Cardiff, "The 'N' Type Injector Pump and the Hydraulic Governor," T. G. Charlesworth, 7 p.m.

Thurs., Dec. 19.—Royal Society of Arts, John Adam Street, London, W.C.2, "Various Trends in Machining and Inspection Methods Concerning the Manufacture of Heavy Commercial Vehicles," R. P. Chilton, 6.30 p.m. ★ YORKSHIRE CENTRE: Great Northern Hotel, Wellington Street, Leeds, 1, "The Design of Vehicles for the Conveyance of Petroleum Products," J. Bellwood, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Tues., Dec. 17.—MANCHESTER BRANCH: Reynolds Hall, College of Science and Technology, Manchester, "Chemical Engineering Aspects of Gas-Solid Reactions," K. G. Denbigh, 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Dec. 17.—Great George Street, Westminster, London, S.W.1, Fourth Graham Clark Lecture, Joint Meeting with Institution of Electrical Engineers and Institution of Mechanical Engineers, "The Engineer and Management," Sir Ewart Smith, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Dec. 13.—EDUCATION DISCUSSION CIRCLE: Savoy Place, London, W.C.2, Discussion on "Basic Experiments on Servo Mechanisms," opened by W. Chellingsworth, 6 p.m. ★ EAST MIDLAND CENTRE: College of Technology, Leicester, Joint Meeting with Leicester Association of Engineers, "Highland Water Power—The Developments of the North of Scotland Hydro-Electric Board," by the late T. Lawrie (to be read by a member of the Board), 7.15 p.m. ★ NORTH SCOTLAND SUB-CENTRE: Robert Gordon's Technical College, Aberdeen, "Choice of Insulation and Surge Protection of Overhead Transmission Lines of 33kV and Above," A. Morris Thomas and D. F. Oakeshott, 7.30 p.m.

Mon., Dec. 16.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, Informal Evening on "Electronics and Automation—Electronics in the Textile Industry," K. J. Butler, 5.30 p.m. ★ MERSEY AND NORTH WALES CENTRE: Town Hall, Chester, "Electrical Floor Warming," J. W. Moule and W. M. Stevenson, 6.30 p.m.

Tues., Dec. 17.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Fourth Graham Clark Lecture, Joint Meeting with Institution of Civil Engineers and Institution of Mechanical Engineers, "The Engineer and Management," Sir Ewart Smith, 5.30 p.m. ★ MEASUREMENT AND CONTROL SECTION: Savoy Place, London, W.C.2 "Recent Uses of Ultrasonics in Investigating the Characteristics of Materials," J. Lamb, 5.30 p.m. ★ S.E. SCOTLAND SUB-CENTRE: Carlton Hotel, North Bridge, Edinburgh, "Ship Stabilisation: Automatic Controls, Computed and in Practice," J. Bell, 7 p.m. ★ NORTH MIDLAND GRADUATE AND STUDENT SECTION: Y.E.B. Offices, Market Street, Huddersfield, "Some Aspects of Grid-Controlled Mercury Arc Rectifiers," J. Bennett, 7 p.m.

Wed., Dec. 18.—SUPPLY SECTION: Savoy Place, London, W.C.2, "The Planning and Construction of Large Modern Thermal Generating Stations," J. Pimpaneau, 5.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Dec. 17.—39, Elmbank Crescent, Glasgow, C.2, "Free-Piston Progress," F. A. I. Muntz and M. Barthalon, 6.30 p.m.

INSTITUTION OF LOCOMOTIVE ENGINEERS

Wed., Dec. 18.—Institution of Mechanical Engineers, 1, Birdcage Walk, London, S.W.1, "American Experience as a Guide to Mainline Locomotive Applications Overseas," H. G. McClean, 5.30 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Dec. 13.—GENERAL MEETING: 1, Birdcage Walk, Westminster, London, S.W.1, James Clayton Lecture, "High-Pressure Hydraulic Transmission," H. Thoma, 6 p.m.

Sat., Dec. 14.—SOUTH WALES BRANCH: Visit to Guest, Keen and Nettlefolds (South Wales), Ltd., Castle Works, Cardiff, 9.30 a.m. ★ MIDLAND GRADUATES' SECTION: Morning visit to Fisher and Ludlow, Ltd., Birmingham.

Mon., Dec. 16.—SCOTTISH A.D. CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, Joint Meeting with the Local Branch of Institution of Civil Engineers, "Vehicle Characteristics and their Relationship to Road Layout," G. Grime, 7.30 p.m.

Tues., Dec. 17.—Institution of Civil Engineers, Great George Street, Westminster, London, S.W.1, Fourth Graham Clark Lecture, Joint Meeting with Institution of Civil Engineers and Institution of Electrical Engineers, "The Engineer and Management," Sir Ewart Smith 5.30 p.m. ★ SOUTH WALES BRANCH: South Wales Institute of Engineers, Park Place, Cardiff, "The Design and Operation of Flying Shears," R. Stewartson, 6 p.m. ★ BIRMINGHAM A.D. CENTRE: James Watt Memorial Institute, Great Charles Street, Birmingham, Discussion on "Miniature Cars in Britain," 6.30 p.m. ★ NORTH-WESTERN GRADUATE SECTION: Engineers' Club, Albert Square, Manchester, "Some Highlights in the History of Mechanical Engineering," E. G. Sterland, 7 p.m.

Wed., Dec. 18.—LONDON GRADUATES' SECTION: Visit to Hovis, Ltd., Vauxhall Bridge Works, London, 2 p.m.

Thurs., Dec. 19.—LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, Technical Film Show, 6.30 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Dec. 19.—Geological Society of London, Burlington House, Piccadilly, London, W.1, "The Lime Addition and Pulp Consistency in Gold Ore Milling," G. Chad Norris, and "The Operation of the Iron Ore Company of Canada," A. Choubersky, 5 p.m.

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Wed., Dec. 18.—Conference Room, Fourth Floor, Waterloo Bridge House, London, S.E.1, "Plant, Personnel and Service—Area Approach to Maintenance," W. H. Owens, 5 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, Dec. 13.—IPSWICH AND COLCHESTER SECTION: Golden Lion Hotel, Cornhill, Ipswich, "A Review of Methods for Heating and Ventilating Factories," F. Carter, 7.30 p.m. ★ DERBY SECTION: College of Art, Derby, "The 'G.F.' Copy Turning Lathe," 7 p.m. ★ SWANSEA SECTION: Central Library, Alexandra Road, Swansea, "Punched Card Development in Automation," D. Nettel, 7.30 p.m.

Mon., Dec. 16.—NEWCASTLE UPON TYNE SECTION: Neville Hall, Newcastle upon Tyne, Film Evening, 7 p.m.

Wed., Dec. 18.—LUTON GRADUATE SECTION: The Mayor's Parlour, Court House, St. Albans, Herts, "The Chemical Removal of Metal," 7.30 p.m.

Thurs., Dec. 19.—NORTHERN IRELAND SECTION: Kensington Hotel, Belfast, "Spark Erosion Technique," E. Foster, 7.30 p.m. ★ GLASGOW SECTION: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Men and Machines," J. E. Hill, 7.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Mon., Dec. 16.—LANCASHIRE AND CHESHIRE BRANCH: College of Science and Technology, Manchester, "A Review of the Structural Steelwork in the 'Seraphim' Extensions at Appleby-Frodingham," S. Richards, 6.30 p.m.

INSTITUTION OF WORKS MANAGERS

Tues., Dec. 17.—MERSEYSIDE BRANCH: Adelphi Hotel, Liverpool, "The Law of Master and Servant," T. Gore, 6.30 p.m. ★ NORTHAMPTON BRANCH: The Franklins Gardens Hotel, Northampton, "Co-Partnership," E. Scott Bader, 7.45 p.m. ★ WOLVERHAMPTON BRANCH: Molineaux Hotel, North Street, Wolverhampton, "Material Handling," H. Partridge, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Dec. 13.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, Inaugural Meeting, Induction of Major-General W. A. Lord as President for 1957–58; Presentation of Awards, 1956–57, by B. Donkin, 7.30 p.m.

Fri., Dec. 20.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "The Use of Computers in Industry," W. V. Barton, 7 p.m.

MANCHESTER ASSOCIATION OF ENGINEERS

To-day, Dec. 13.—Engineers' Club, Albert Square, Manchester, 2, "Chemical Engineering Education," F. Morton, 6.45 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Dec. 13.—Lecture Theatre, Mining Institute, Newcastle upon Tyne, "The Analysis of Structures with Particular Reference to the Prediction of Deflections," T. M. Charlton, 6.15 p.m.

Mon., Dec. 16.—TEES-SIDE BRANCH: Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, Film on "M.S. 'Bergensfjord,'" 6 p.m.

PLASTICS INSTITUTE

Tues., Dec. 17.—LONDON SECTION: Wellcome Building, 183–193, Euston Road, London, N.W.1, "The Plastics Institute, Press and Industry," C. W. Welch, 6.30 p.m.

Wed., Dec. 18.—SCOTTISH SECTION: More's Hotel, Glasgow, "Akulon-Type 6 Nylon," R. van der Spek, 7.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Tues., Dec. 17.—MIDLAND COUNTIES BRANCH: Birmingham and Midland Institute, Paradise Street, Birmingham, "Some Reinforced Concrete Works in Europe and Asia," N. A. Sadleir, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Tues., Dec. 17.—The Library, 4, Hamilton Place, London, W.1, Section Lecture, "Comparison of Ducted Fan, By-pass and Straight Jet Engines," S. G. Hooker, 7 p.m.

ROYAL METEOROLOGICAL SOCIETY

Wed., Dec. 18.—49, Cromwell Road, South Kensington, London, S.W.7, "Dew," J. L. Monteith, and "Water Losses from Various Land Surfaces," N. E. Rider, 5 p.m.

ROYAL SOCIETY OF ARTS

Wed., Dec. 18.—John Adam Street, Adelphi, London, W.C.2, "Sir George Cayley (1773–1857): A Pioneer of Science and Engineering," J. Laurence Pritchard, 2.30 p.m.

ROYAL STATISTICAL SOCIETY

Tues., Dec. 17.—London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, "The Depreciation and Mortality of Motor Cars," J. S. Cramer, 5.15 p.m.

Wed., Dec. 18.—RESEARCH SECTION: Large Chemistry Theatre, University College, Gower Street, London, W.C.1, "Statistical Approach to Cosmology," J. Neyman and Elizabeth Scott, 5.15 p.m.

SHEFFIELD METALLURGICAL ASSOCIATION

Tues., Dec. 17.—B.I.S.R.A., Hoyle Street, Sheffield, Films, 7 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Wed., Dec. 18.—CORROSION GROUP: 14, Belgrave Square, London, S.W.1, Discussion on "Teaching Corrosion Science," 2.30–4 p.m., "Existing Facilities for Training in Corrosion Science," opened by L. W. Stubbs; 4.45–6.30 p.m., "Future Requirements," opened by T. P. Hoar.

Thurs., Dec. 19.—ROAD AND BUILDING MATERIALS GROUP: 14, Belgrave Square, London, S.W.1, "The Whiting-Oil Relationship in Glazing Putty," D. C. Soul and R. R. Davidson, and "The Examination of Building Mastics and Similar Compositions," J. Bowler-Reed, 6 p.m.

WEST OF SCOTLAND IRON AND STEEL INSTITUTE

Fri., Dec. 20.—39, Elmbank Crescent, Glasgow, C.2, "Electric Melting Furnaces," F. S. Leigh, 6.45 p.m.

Advanced Engineering Courses

Engineering and Metallurgical Aspects of Fatigue. BATTERSEA COLLEGE OF TECHNOLOGY, METALLURGY DEPARTMENT, Battersea Park Road, London, S.W.11. Course of ten lectures, Tuesdays, 7 to 9 p.m., commencing January 14, 1958. The course is designed to cover both modern industrial practice and recent theoretical developments. Fee £1.

Production Planning and Control. UNIVERSITY OF BIRMINGHAM, Institute for Engineering Production, "Southfield," 16, Norfolk Road, Edgbaston, Birmingham, 15. From 9.30 a.m., Monday, December 9, to 4 p.m., Friday, December 20. Fee £50 (residential).

Modern Electric Network Theory and Design. SOUTH EAST LONDON TECHNICAL COLLEGE, DEPARTMENT OF ELECTRICAL ENGINEERING AND APPLIED PHYSICS, Lewisham Way, London, S.E.4. Course of six lectures, Wednesdays, 7 to 9 p.m., commencing January 22. Fee 10s.

Dynamical Similarity and Dimensional Analysis. DEPARTMENT OF MECHANICAL ENGINEERING, Brownlow Hill, The University, Liverpool. A University extension course of ten lectures, Tuesdays, 5.30 to 7 p.m., commencing January 7. Fee £2 12s. 6d.

Introduction to Electronics. DEPARTMENT OF ELECTRICAL ENGINEERING, Brownlow Hill, The University, Liverpool. A University extension course of ten lectures, Fridays, 5.30 to 7 p.m., commencing January 10. Fee £2 12s. 6d.